DOCUMENT RESUME

ED 128 624 CE 007 944

AUTHOR	Emerly, Robert J.; And Others
TITLE	Machine Shop Practice. Trade and Industrial Education Course of Study.
INSTITUTION	Pennsylvania State Dept. of Education, Harrisburg. Bureau of Vocational Education.; Pennsylvania State Univ., University Park. Dept. of Vocational Education.
PUB DATE	73
NOTE	289p.
EDRS PRICE	MF-$0.83 HC-$15.39 Plus Postage.
DESCRIPTORS	*Curriculum Guides; *Learning Activities; *Machine Tools; *Mechanics (Process); Secondary Education; *Shop Curriculum; *Teaching Guides; Technical Education; Trade and Industrial Education; Vocational Education

ABSTRACT

Designed for secondary school students who are interested in becoming machinists, this beginning course guide in machine shop practice is organized into the following sections: (1) Introduction, (2) instructional plan, (3) educational philosophy, (4) specific course objectives, (5) course outline, (6) job sheets, and (7) operation sheets. The course outline calls for 470 hours of applicatory jobs to be completed by students; 35 hours of skill development lessons and 35 hours of information lessons are to be presented by the instructor. For each of the 73 applicatory jobs, a job sheet is included that tells the student what to do in performing the job. The job sheet contains a photograph and scale drawing of the tool, equipment list, list of tools needed, safety precautions, and procedures. Operation sheets supplement the job sheets and tell the student how to perform the operations necessary to complete the assigned jobs. Keyed to the skill development lessons, each operation sheet lists the tools and equipment, and procedure for a specific operation, along with an introductory explanation. The eight units covered are: Lathe operation, power saw operation, bench work, milling machine operation, shaper operation, drilling machine operation, surface grinder operation, and heat treatment. Suggested information lesson titles are listed, but information sheets and assignment sheets are to be prepared by the instructor. (Author/RG)

****
* Documents acquired by ERIC include many informal unpublished *
* materials not available from other sources. ERIC makes every effort *
* to obtain the best copy available. Nevertheless, items of marginal *
* reproducibility are often encountered and this affects the quality *
* of the microfiche and hardcopy reproductions ERIC makes available *
* via the ERIC Document Reproduction Service (EDRS). EDRS is not *
* responsible for the quality of the original document. Reproductions *
* supplied by EDRS are the best that can be made from the original. *
****

ED128624

TRADE AND INDUSTRIAL EDUCATION

COURSE OF STUDY

FOR

MACHINE SHOP PRACTICE

COMPILED BY

Robert J. Emerly
Clearfield County Area Vocational-Technical School

M. William Golder
Columbia-Montour Area Vocational-Technical School

Charles R. Skovira
Carlisle Area Senior High School

IN COOPERATION WITH

Department of Vocational Education
College of Education
The Pennsylvania State University

AND

Department of Education
Bureau of Vocational Education
Harrisburg, Pennsylvania

U.S. DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

CE 007 944

1973

Commonwealth of Pennsylvania
  Milton J. Shapp, Governor

Department of Education
  John C. Pittenger, Secretary

Office of Basic Education
  Donald M. Carroll, Jr., Commissioner
  Harry K. Gerlach, Deputy Commissioner

Bureau of Vocational Education
  John W. Struck, Director

Vocational Program Development Division
  William P. Hartman, Chief

Trade and INdustrial Education
  Robert Jacoby, Senior Program Specialist

Pennsylvania Department of Education
Box 911
Harrisburg, Pa. 17126

PREFACE

In recent years the finest of vocational education building facilities have been planned and constructed in the Commonwealth of Pennsylvania, and in these buildings the best available equipment has been installed. Equal attention must now be directed to provide the vocational teacher with the basic tools for quality instruction.

This basic course of study is intended to be used by the teacher as a teaching guide. The information provides the essentials of the occupation, insuring that the students who successfully complete the course will have sufficient competencies for entry employment, and ample orientation for growth and advancement in the labor market. The teacher who uses this course of study will want to modify and supplement the material to meet the specific needs of students and the industrial community.

William A. Williams, Head
Department of Vocational Industrial Education
The Pennsylvania State University
University Park, Pennsylvania 16802

January 1973

TABLE OF CONTENTS

Section Page

1. INTRODUCTORY STATEMENT 1
2. PLAN OF INSTRUCTIONAL PRACTICES 2
3. STATEMENT OF EDUCATIONAL PHILOSOPHY 4
4. SPECIFIC COURSE OBJECTIVES 5
5. COURSE OUTLINE 6
    A. Applicatory Jobs 7
    B. Skill Development and Information Lessons 10
6. JOB SHEETS 15
7. OPERATION SHEETS 259
8. INFORMATION SHEETS AND ASSIGNMENT SHEETS 431

Section 1

INTRODUCTORY STATEMENT

This course is intended for secondary school students who are interested in securing employment as machinists. It is designed as a beginning course in machine shop practice, and would usually be offered to tenth grade students.

The course is designed to give the students an opportunity to:

1. develop the necessary skills required to perform the tasks of the machinist,
2. acquire the related information necessary to exercise good judgment in carrying out the construction, maintenance, servicing and repairing operations required of the machinist,
3. develop an appreciation of good workmanship, safety, and correct work habits and attitudes.

This course will be conducted as a part of the vocational education program of a school district, and will be administered through the facilities of the local vocational program as a trade preparatory course.

Section 2

PLAN OF INSTRUCTIONAL PRACTICES

Introduction

In presenting this course for the training of machinists, certain instructional practices will be employed. These practices are presented to insure the most effective instructional program. From time to time, some of the practices recommended may be altered to meet required changes in instructional situations and to meet changes in the technological phases of the occupation.

Teaching Methods

To achieve the desired objectives of this course, the following teaching methods will be employed:

1. Demonstrations--accurate portrayals of procedures or manipulative operations. In the process of teaching, demonstrations show how things are done, and show them in such a way that students will learn the procedures and operations.

2. Class Discussions--a method of teaching in which the members of a class and a teacher take part, directed and controlled by the teacher toward a predetermined goal, with most of the ideas contributed by the class. This method is used in the presentation of related information, reports of field trips, and class organizational problems.

3. Shop Talks--an informal lecture used by the teacher in a shop atmosphere for the presentation of related technical information. Shop talks should be relatively short--not more than twenty minutes.

Teaching Aids

To provide a more effective presentation of skills and related technical information, the following types of teaching aids will be used:

1. Reference books

2. Job sheets, operation sheets, information sheets and assignment sheets

3. Charts, graphs, prints, posters

4. Strip film and slide film projectors

5. Overhead projectors
6. Motion picture projectors
7. Models and mock-ups
8. Manufacturers literature

Vehicles of Instruction

The application phase of this course will consist of jobs and exercises assigned to students for completion. To provide for individual differences, job sheets, operation sheets, information sheets and assignment sheets will be used. Unusually capable students will be encouraged to work on special jobs of an advanced nature. Each student will be permitted to progress at his own natural learning rate, with special attention given to the slow learner.

Average Size of Class

This course is designed for a class of not more than twenty-five students per shop instructor.

Physical Facilities Required

A shop room with an area of not less than 2,700 - 3,000 square feet will be required. In addition, a small classroom of 425 square feet, to accommodate twenty-five students, will be provided.

Section 3

STATEMENT OF EDUCATIONAL PHILOSOPHY

Educational Philosophy of the School System

The primary function of the educational program in any community is the development of the individual citizen, youth or adult, in all his capacities, so that he will be a good member of the community and of the larger democracy of which he is a part.

Basic Philosophy of Vocational Education

Vocational education, as an integral part of the total education program of the community, makes a contribution toward the development of good citizens--including their health, social, civic, cultural and economic interests. Its chief purpose is to prepare individuals for gainful employment through the development of skills, knowledges, understandings, attitudes, work habits, appreciations, leadership qualities and citizenship qualities.

Basic Philosophy of Vocational Industrial Education

Vocational industrial education is a phase of vocational education that provides instruction and experience for the purpose of fitting persons for gainful employment in trade, technical and industrial pursuits. The major objectives of this program are as follows:

1. To provide instruction of a preparatory type in the development of basic manipulative skills, safety judgment, technical knowledge, and related technical information for the purpose of fitting persons for gainful employment.
2. To provide instruction of an extension type for the further development of performance skills, technical knowledge, related technical information, safety, and job judgment for persons already employed.

Instruction in vocational industrial education is provided for four general groups:

1. Journeymen and other industrial workers who need extension instruction in industrial subjects.
2. Apprentices and other learners who need instruction in trade, technical and industrial subjects.
3. Out-of-school youth who need training and experiences, coordinated by public school authorities, to fit them for gainful employment.
4. In-school youth who have selected an occupation and who need training for entrance into a trade, technical or industrial pursuit.

This course for the training of machinists falls under the fourth category.

Section 4

SPECIFIC COURSE OBJECTIVES

Objectives	Activities to Achieve Objectives
1. To develop specific skills and related information associated with the occupation of machinist	1. Series of individual jobs 2. Series of practice exercises 3. Use of job sheets, operation sheets, information sheets and assignment sheets for individual students
2. To develop an understanding of labor and management	1. Assign reading in trade magazines 2. Arrange for talks by representatives of labor and management 3. Schedule discussions on problems dealing with a. Labor unions b. Responsibilities of management
3. To develop good habits of work	1. Provide specific standards for each job or exercise 2. Maintain a clean, well-organized shop area and classroom which are conducive to effective learning 3. Discuss with students the importance of good work habits and their relationship to industrial practice and shop advancement 4. Evaluate students' work objectively 5. Provide a means for students to plan their work accurately and methodically
4. To develop occupational safety habits and understandings	1. Display safety posters 2. Provide safety devices for all hazardous work activity 3. Demonstrate correct safety practice whenever appropriate 4. Show motion picture on effective safety practices
5. To develop the ability to work cooperatively with fellow workers	1. Set up a maximum of class and group projects 2. Encourage students to seek help from each other 3. Provide student planning committees 4. Assign the more advanced students to assist students needing help
6. To stimulate the development of leadership qualities	1. Provide opportunity for students to plan their assigned work jobs and write their own job sheets 2. Provide a plan for students to appraise their own work

Section 5

COURSE OUTLINE

The course is developed in the following areas with the appropriate time distribution:

A.	Applicatory Jobs - completed by students	470 hours
B.	Skill Development Lessons - presented by instructor	35 hours
C.	Information Lessons - presented by instructor	35 hours

A. APPLICATORY JOBS

With a total of approximately 470 hours allowed for applicatory jobs, an average of 7.5 hours would therefore be available for each of the following: (these are job titles only--the numbers preceding each title correspond with the identifying numbers found on the job sheets included in Section 6 of this course of study).

J-1-10-1	Drill Drift
J-2-10-2	Tool Post Wrench
J-3-10-3	Cross-peen Hammer
J-4-10-4	Idler Shaft
J-5-10-5	Stud Bolt
J-6-10-6	Can Punch
J-7-10	Depth Gauge
J-7-10-7	Depth Gauge--Base
J-7-10-8	Depth Gauge--Handle
J-7-10-9	Depth Gauge--Screw
J-7-10-10	Depth Gauge--Rod
J-8-10	C-Clamp
J-8-10-11	C-Clamp--Body
J-8-10-12	C-Clamp--Screw
J-8-10-13	C-Clamp--Screw Cap
J-8-10-14	C-Clamp--Handle
J-9-10-15	Drill Grinding Gauge
J-10-10	Parallel Clamp
J-10-10-16	Parallel Clamp--Threaded Jaw
J-10-10-17	Parallel Clamp--Loose Jaw
J-10-10-18	Parallel Clamp--Straight Clip
J-10-10-19	Parallel Clamp--Adjusting Screw
J-10-10-20	Parallel Clamp--Clamping Screw

J-11-10	Tap Wrench
J-11-10-21	Tap Wrench--Handles
J-11-10-22	Tap Wrench--Screws
J-12-10-23	Punch Set
J-13-10-24	Cold Chisel
J-14-10	Ball Peen Hammer
J-14-10-25	Ball Peen Hammer--Head
J-14-10-26	Ball Peen Hammer--Handle
J-14-10-27	Ball Peen Hammer--Handle Plug
J-15-10	Jack Screw
J-15-10-28	Jack Screw--Base
J-15-10-29	Jack Screw--Sleeve
J-15-10-30	Jack Screw--Screw
J-15-10-31	Jack Screw--Swivel
J-16-10	Meat Tenderizer
J-16-10-32	Meat Tenderizer--Head
J-16-10-33	Meat Tenderizer--Handle
J-17-10-34	Lathe Centers
J-18-10	Scriber
J-18-10-35	Scriber--Nose
J-18-10-36	Scriber--Plug
J-18-10-37	Scriber--Point
J-18-10-38	Scriber--Body
J-19-10-39	Plumb Bob
J-20-10	Paper Punch
J-20-10-40	Paper Punch--Body
J-20-10-41	Paper Punch--Base

J-20-10-42	Paper Punch--Punch
J-20-10-43	Paper Punch--Cap
J-20-10-44	Assembly of Paper Punch
J-21-10	Center Finder
J-21-10-45	Center Finder--Cap
J-21-10-46	Center Finder--Ball
J-21-10-47	Center Finder--Point
J-21-10-48	Center Finder--Insert
J-21-10-49	Center Finder--Shank
J-22-10	Wheel Puller
J-22-10-50	Wheel Puller--Yoke
J-22-10-51	Wheel Puller--Legs
J-22-10-52	Wheel Puller--Screw
J-22-10-53	Wheel Puller--Knobs
J-22-10-54	Wheel Puller--Handle
J-22-10-55	Wheel Puller--Leg Screws
J-22-10-56	Wheel Puller--Point
J-23-10	Tool Makers Vise
J-23-10-57	Tool Makers Vise--Body
J-23-10-58	Tool Makers Visc--Movable Jaw
J-23-10-59	Tool Makers Vise--Sliding Plate
J-23-10-60	Tool Makers Vise--Screw
J-23-10-61	Tool Makers Vise--Hardened Jaws

SKILL DEVELOPMENT AND INFORMATION LESSONS

Approximately 35 hours of instruction time are necessary for teacher demonstration of the Skill Development Lessons and approximately 35 hours for Information Lessons presented by the instructor. The numbers preceding each title correspond to the identifying numbers of the operation sheets and information sheets. Suggested information lesson titles are listed. Each instructor should prepare his own information lessons due to the personal nature of said lessons. Therefore, no information sheets are included as a part of this document.

B. Skill Development Lessons

Unit I -- Lathe Operation

SL-1-1	Drilling Center Holes on the Lathe
SL-1-2	Mounting Work Between Centers
SL-1-3	Facing Ends Between Centers
SL-1-4	Turning Between Centers
SL-1-5	Aligning Lathe Centers
SL-1-6	Turning Shoulders on the Lathe
SL-1-7	Rounding and Chamfering Turned Edges
SL-1-8	Turning Grooves on the Lathe
SL-1-9	Filing and Polishing on the Lathe
SL-1-10	Knurling on the Lathe
SL-1-11	Threading on the Lathe
SL-1-12	Turning Angles with the Compound Rest
SL-1-13	Turning Tapers by Offset Tailstock Method
SL-1-14	Mounting Work on a Mandrel
SL-1-15	Truing Work in the Lathe Chuck
SL-1-16	Using Draw-in Collets
SL-1-17	Facing Chuck Work on the Lathe

C. Information Lessons

Unit I -- Lathe Operation

IL-1-1	History of the Lathe
IL-1-2	Lathe Types & Construction
IL-1-3	Types & Kinds of Workholding Devices
IL-1-4	Types and Kinds of Lathe Accessories
IL-1-5	Care of Lathes & Personal Safety
IL-1-6	High Speed Single Point Cutting Tools
IL-1-7	Description of Speeds & Feeds on the Lathe
IL-1-8	Types of Centering Tools
IL-1-9	Description of Center Holes
IL-1-10	Description of Lathe Centers
IL-1-11	Types & Kinds of Knurls Used on the Lathe
IL-1-12	Common Terms Used in the Measurement of Angles
IL-1-13	Rules for Figuring Taper Turning with Tailstock Offset
IL-1-14	Rules for Figuring Tapers
IL-1-15	Description of Taper Turning with Taper Attachment

B. Skill Development Lessons

SL-1-18 Drilling on the Lathe
SL-1-19 Boring on the Lathe
SL-1-20 Reaming on the Lathe
SL-1-21 Tapping on the Lathe
SL-1-22 Cutting Off Stock on the Lathe
SL-1-23 Changing Feeds on the Lathe
SL-1-24 Changing Speeds on the Lathe
SL-1-25 Mounting a Lathe Chuck
SL-1-26 Grinding Lathe Tools
SL-1-27 Using Taper Attachment

Unit 2 -- Power Saw Operation

SL-2-1 Cutting Off Material
SL-2-2 Cutting to a Layout

Unit 3 -- Bench Work

SL-3-1 Measuring--Linear
SL-3-2 Sawing with a Hand Hacksaw
SL-3-3 Squaring
SL-3-4 Using Layout Tools
SL-3-5 Laying Out
SL-3-6 Filing
SL-3-7 Threading with Hand Dies
SL-3-8 Measuring - Micrometers
SL-3-9 Chipping

C. Information Lessons

IL-1-16 Depth Settings for Cutting Threads on the Engine Lathe
IL-1-17 Description of the Thread-Chasing Dial
IL-1-18 Description of Graduated Collars
IL-1-19 Description and Setting of the Compound Rest

Unit 2 -- Power Saw Operation

IL-2-1 Types & Kinds of Power Saws
IL-2-2 Types & Kinds of Blades for Power Saws
IL-2-3 Safety Precautions on Power Saws

Unit 3 -- Bench Work

IL-3-1 Using Linear Measurement
IL-3-2 The Meaning of a Decimal
IL-3-3 The Use and Care of Micrometer Calipers
IL-3-4 Using the Dial Indicator
IL-3-5 Shapes of Stock
IL-3-6 Kinds of Metals and How to Identify Them
IL-3-7 Reading a Drawing & Planning Your Work

B. Skill Development

SL-3-10 Polishing

SL-3-11 Tapping by Hand

SL-3-12 Burring

SL-3-13 Using a Pedestal Grinder

Unit 4 -- Milling Machine Operation

SL-4-1 Milling a Flat Surface

SL-4-2 Squaring and Indicating a Vise

SL-4-3 Drilling on the Milling Machine

SL-4-4 Calibrating on the Milling Machine

SL-4-5 Slotting on the Milling Machine

C. Information Lessons

IL-3-8 Types & Kinds of Hammers

IL-3-9 Use and Care of Calipers

IL-3-10 Use and Care of Surface Plates

IL-3-11 Description & Use of Scribers

IL-3-12 Description of Layout Punches

IL-3-13 Using the Surface Gauge

IL-3-14 Safety Rules for Bench Work

IL-3-15 Types & Kinds of Hand Hacksaw Blades

IL-3-16 Kinds of Chisels

IL-3-17 Types & Kinds of Files

IL-3-18 Kinds of Abrasives

IL-3-19 Screw-Thread Terms & Definitions

IL-3-20 Screw-Thread Forms

IL-3-21 Description of Taps & Dies

IL-3-22 Dressing & Truing Grinding Wheels on the Pedestal Grinder

Unit 4 -- Milling Machine Operation

IL-4-1 Types & Construction of Milling Machines

IL-4-2 Cutter-Holding Devices for the Milling Machine

IL-4-3 Description of Workholding Devices

IL-4-4 Description of Milling Cutters (Plain, Slotting, Form)

B. Skill Development Lessons

SL-4-6	Counterboring on the Milling Machine
SL-4-7	Reaming on the Milling Machine (Vertical)
SL-4-8	Seating a Work Piece in a Vise on Milling Machine
SL-4-9	Mounting the Milling Cutter
SL-4-10	Mounting a Vise on the Milling Machine Table
SL-4-11	Dismounting a Vise on the Milling Machine Table
SL-4-12	Dismount a Milling Cutter
SL-4-13	Mount and Dismount a Milling Machine Arbor

Unit 5 -- Shaper Operation

SL-5-1	Shaping a Horizontal Surface
SL-5-2	Adjusting the Stroke and Position of the Ram
SL-5-3	Grinding Shaper Tools
SL-5-4	Adjusting the Speeds & Feeds on the Shaper

Unit 6 -- Drilling Machine Operation

SL-6-1	Drilling on the Drill Press
SL-6-2	Reaming on the Drill Press
SL-6-3	Countersinking on the Drill Press
SL-6-4	Grinding a Drill

C. Information Lessons

IL-4-5	Description of Speeds & Feeds on the Milling Machine
IL-4-6	Safety Precautions for Milling Machine

Unit 5 -- Shaper Operation

IL-5-1	Construction & Types of Shapers
IL-5-2	Description of Shaper Workholding Devices
IL-5-3	Description of Shaper Speeds & Feeds
IL-5-4	Safety Precautions on the Shaper

Unit 6 -- Drilling Machine Operation

IL-6-1	Drill Press Types & Construction
IL-6-2	Description of Drills & Drilling Fundamentals
IL-6-3	Description of Speeds, Feeds and Coolant for Drilling
IL-6-4	Reamers--Types and Selection

B. Skill Development Lessons

Unit 7 -- Surface Grinder Operation

SL-7-1 Using a Permanent Magnet Chuck

SL-7-2 Grinding a Flat Surface

SL-7-3 Dressing the Grinding Wheel

SL-7-4 Squaring Stock on the Surface Grinder

SL-7-5 Mounting a Grinding Wheel

Unit 8 -- Heat Treatment

SL-8-1 Hardening and Tempering Steel

SL-8-2 Case-Hardening Steel

SL-8-3 Annealing Steel

C. Information Lessons

IL-6-5 Types of Cutters Used on Drill Press

IL-6-6 Description of Work-holding Devices

IL-6-7 Description of Cutter-Holding Devices

IL-6-8 Safety Precautions on the Drill Press

Unit 7 -- Surface Grinder Operation

IL-7-1 Description of Work-holding Devices

IL-7-2 Grinding Wheel Construction

IL-7-3 Care & Use of Grinding Wheels

IL-7-4 Dressing & Truing Grinding Wheels

IL-7-5 Safety Precautions on the Surface Grinder

Unit 8 -- Heat Treatment

IL-8-1 Description Heat-Treating Methods

IL-8-2 Types of Heat-Treating Furnaces

IL-8-3 Description of Steel and its Alloys

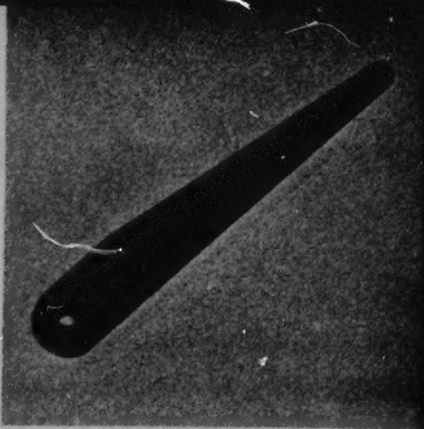
IL-8-4 Kinds and Types of Hardness Testing Machines

IL-8-5 Table of Temperatures and Corresponding Colors for Tempering Tool Steel

Section 6

JOB SHEETS

Job Sheets indicate to the student what to do in performing the various jobs assigned by the teacher. The jobs that will be used as vehicles of instruction in this course are listed in Section 5. The job sheets included in this section (Section 6) are numbered to correspond with the applicatory jobs listed in the COURSE OUTLINE.



JOB SHEET

Job No. J-1-10-1 Drawing No. 1-10A1

DRILL DRIFT

EQUIPMENT: Power cutoff saw, heat treating furnace, bench vise, and drill press.

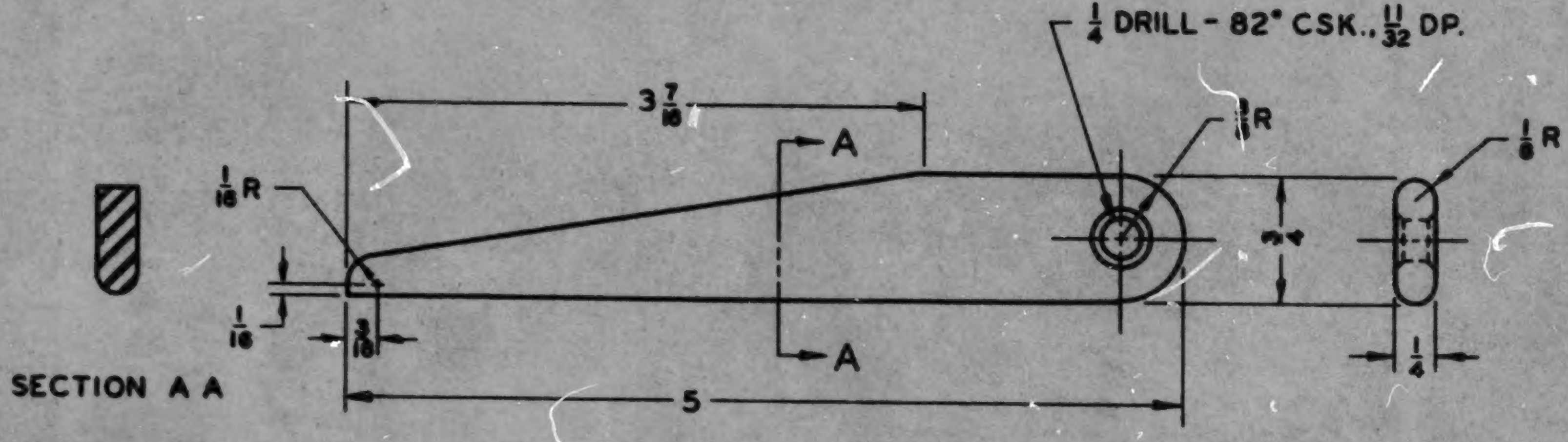
TOOLS:
- tongs
- scriber
- file card
- layout dye
- 1/4" drill
- prick punch
- 3" dividers
- cutting oil
- hand hacksaw
- center punch
- layout hammer
- 6" steel rule
- abrasive cloth
- asbestos gloves
- 82° countersink
- 10" mill file
- 10" flat file
- case hardening compound

SAFETY PRECAUTIONS:

1. Sharp tools are safer to use than dull ones.
2. Always inspect scribers, prick punches, and dividers before using them.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select 1/4" by 3/4" C.R. steel.
2. Cut off stock 5-1/8" long on power cutoff saw, allowing 1/8" for squaring (refer to Operation Sheet Nos. SL-2-1 and SL-3-1).
3. Remove burrs (refer to Operation Sheet No. SL-3-12).
4. Layout as per print (refer to Operation Sheet Nos. SL-3-4 and SL-3-5).
5. Drill 1/4" diameter hole and countersink both sides (refer to Operation Sheet Nos. SL-6-1, 3, and 4).
6. Saw approximately 1/32" outside of layout lines (refer to Operation Sheet No. SL-2-2).
7. File piece to layout lines (refer to Operation Sheet No. SL-3-6).
8. Finish file, draw file all surfaces.
9. Polish with abrasive cloth (refer to Operation Sheet No. SL-3-10).
10. Case harden (refer to Operation Sheet No. SL-8-2).
11. Repolish with abrasive cloth.
12. Inspect as per print.


1/4 DRILL - 82° CSK., 11/32 DP.
3 7/16
A
A
3/8 R
1/8 R
1/16 R
3/4
1/4
1/16
3/16
5
SECTION A A

MATERIAL- AISI 1018 C.R.S.
HEAT TREATMENT - CASE HARDEN

SCALE: 1 = 1 DATE: 12-26-70	APPROVED BY:	DRAWN BY D.G.H. REVISED

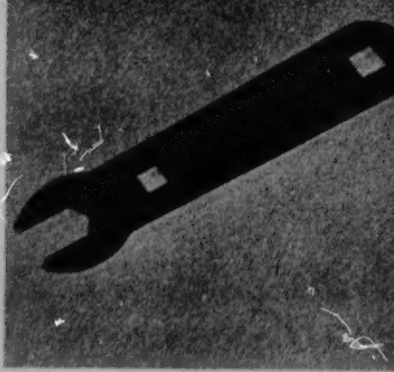
DRILL DRIFT

SHEET 1 OF 1

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ±1/64
DECIMAL DIMENSIONS ±.005
ANGULAR DIMENSIONS ±1/2

DRAWING NUMBER
1-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



JOB SHEET

Job No. J-2-10-2 Drawing No. 2-10A1

TOOL POST WRENCH

EQUIPMENT: Power cutoff saw, drill press, bench vise, and heat treating furnace.

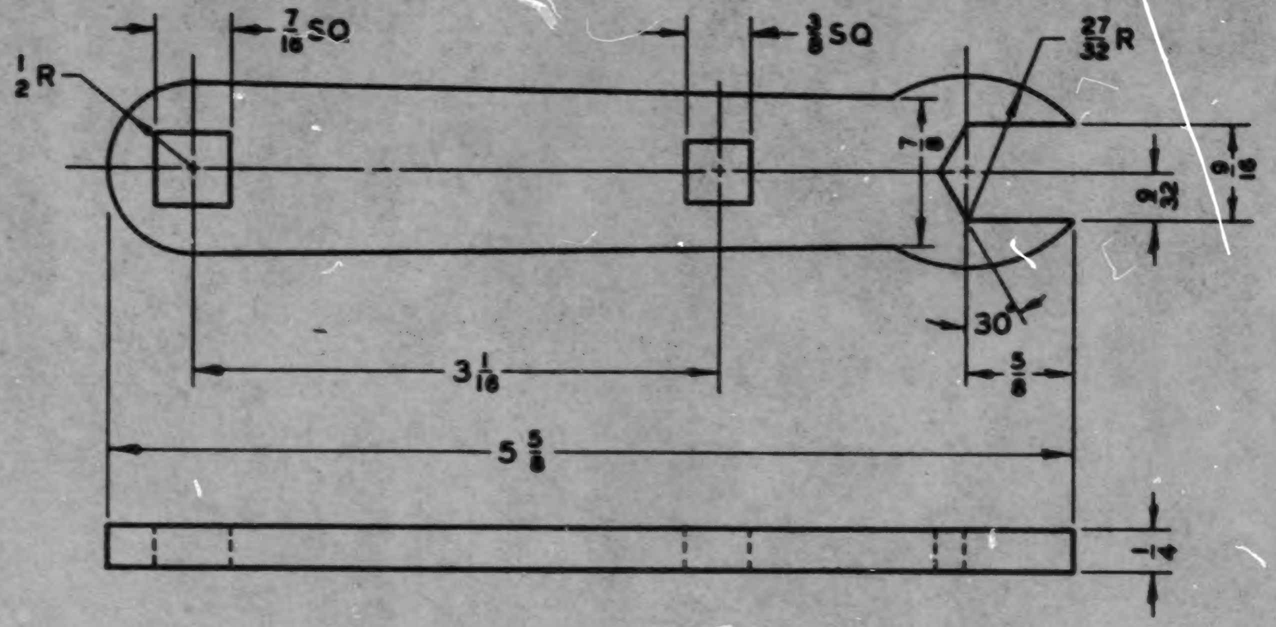
TOOLS:
- tongs
- scriber
- file card
- layout dye
- protractor
- 3/8" drill
- 1/2" drill
- cutting oil
- 5/16" drill
- 3" dividers
- prick punch
- hand hacksaw
- center punch
- 6" steel rule
- abrasive cloth
- asbestos gloves
- ball peen hammer
- 10" mill file
- 6" flat file
- 10" flat file
- 6" square file
- 3/8", 1/2", 9/16" square key steel

SAFETY PRECAUTIONS:

1. Clamp all work securely in machines.
2. Observe all shop safety rules.
3. Do not use a file without a tight fitting handle.
4. Check all dimensions carefully to limit material loss.
5. Operate no equipment without authority to do so.

PROCEDURE:

1. Select and cut stock 1/4" x 1-1/4" x 5-3/4" on power cutoff saw.
2. Remove all burrs.
3. Layout as per print.
4. Prick punch center holes for drills, check prick punch mark for proper location, then center punch.
5. Drill 3/8" hole in 7/16" square.
6. Drill 5/16" hole in 3/8" square.
7. Drill 1/2" hole in 9/16" jaw opening.
8. Saw within 1/32" of layout lines except at radii, using the hand hacksaw (refer to Operation Sheet No. SL-3-2).
9. File to layout lines.
10. File and fit 9/16" jaw opening to gauge.
11. File and fit 3/8" and 7/16" square openings to gauges.
12. Draw file all surfaces to a smooth finish.
13. Polish with abrasive cloth.
14. Case harden.
15. Repolish with abrasive cloth.
16. Inspect as per print.


$\frac{1}{2}$ R
$\frac{7}{16}$ SQ
$\frac{3}{8}$ SQ
$\frac{27}{32}$ R
$\frac{7}{8}$
$\frac{9}{32}$
$\frac{9}{16}$
30°
$3\frac{1}{16}$
$\frac{5}{8}$
$5\frac{5}{8}$
$\frac{1}{4}$

MATERIAL - AISI 1018 C.R.S.

SCALE: 1 = 1 DATE: 12-26-70	APPROVED BY:	DRAWN BY D.G.H. REVISED

TOOL POST WRENCH

SHEET 1 OF 1	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1 2	DRAWING NUMBER 2-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-3-10-3 Drawing No. 3-10A1

CROSS PEEN HAMMER

EQUIPMENT: Power cutoff saw, drill press, vertical band saw.

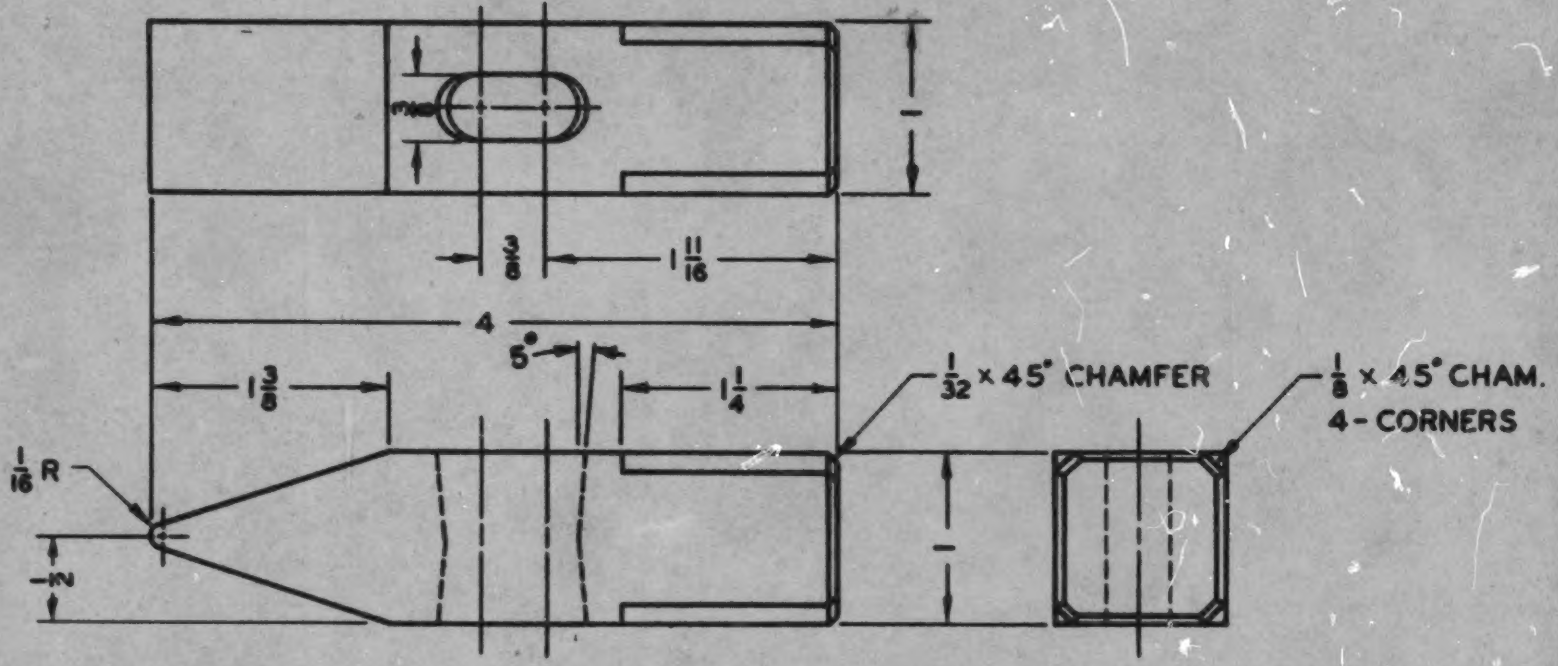
TOOLS:
layout dye
scriber
3" dividers
6" steel rule
prick punch
center punch
file card
3/8" drill
cutting oil
drill vise
abrasive cloth
asbestos gloves
tongs
ball peen hammer
10" flat second cut file
10" round second cut file
10" square second cut file
6" combination square
case hardening compound

SAFETY PRECAUTIONS:

1. Check all dimensions carefully to limit material loss.
2. Hold all work securely before drilling.
3. Use forging tongs when loading or unloading a furnace.
4. Remember, everything in the heat treating area is hot until proven otherwise.
5. Operate no equipment without authority to do so.

PROCEDURE:

1. Select 1" square C.R. steel.
2. Cut to 4-1/8" long on power cutoff saw.
3. File end square and to length (refer to Operation Sheet No. SL-3-3).
4. Layout for drilling holes for handle hole.
5. Drill for handle hole.
6. File out handle hole to layout lines. Be careful to maintain double taper in hole.
7. Layout all chamfers on face end of hammer.
8. File all chamfers to layout.
9. Layout cross peen end of hammer.
10. Saw to within 1/32" of layout lines on vertical band saw.
11. File to layout lines.
12. File radius on cross peen.
13. Polish with abrasive cloth.
14. Inspect as per print.
15. Case harden.
16. Repolish with abrasive cloth.
17. Install handle.


3/8
1
3/8
1 11/16
4
5°
1 3/8
1 1/4
1/32 × 45° CHAMFER
1/8 × 45° CHAM.
4-CORNERS
1/16 R
1/2
1

MATERIAL - AISI-1018 C.R.S.

SCALE: 1 = 1
DATE: 12-27-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

CROSS PEEN HAMMER - HEAD

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2°

DRAWING NUMBER 3-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-4-10-4 Drawing No. 4-10A1

IDLER SHAFT

EQUIPMENT: Lathe, power cutoff saw.

TOOLS:
- lathe dog
- file card
- 6" steel rule
- #3 center drill
- 1/16" radius tool
- 3" outside caliper
- 10" mill file
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper shank to fit lathe tailstock spindle

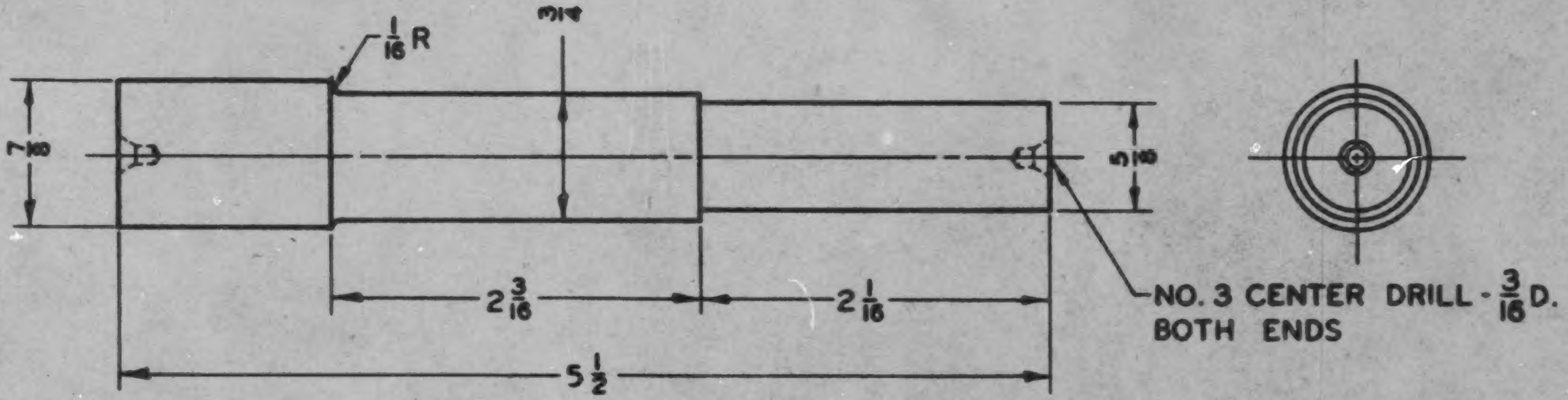
SAFETY PRECAUTIONS:

1. Observe all shop safety rules.
2. Do not check O.D. with calipers while the lathe is running.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select 1" diameter C.R. steel, cut to 5-5/8" length on power cutoff saw.
2. Mount work piece in 3 jaw universal chuck (refer to Operation Sheet No. SL-1-25).
3. Select proper spindle speed and feed (refer to Operation Sheet Nos. SL-1-23 and SL-1-24).
4. Face one end (refer to Operation Sheet Nos. SL-1-13, 17, and 26).
5. Center drill (refer to Operation Sheet No. SL-1-1).
6. Reverse work piece in chuck.
7. Layout length as per print.
8. Face to 5-1/2" length.
9. Center drill.
10. Mount work piece between centers (refer to Operation Sheet Nos. SL-1-2 and SL-1-5).
11. Turn 7/8" diameter as close to lathe dog as possible (refer to Operation Sheet No. SL-1-4).
12. Reverse work piece between centers.
13. Turn 3/4" diameter 2-3/16" long (refer to Operation Sheet No. SL-1-6).
14. Form 1/16" radius between 7/8" diameter and 3/4" diameter.
15. Turn 5/8" diameter 2-1/16" long.
16. Break all sharp edges.
17. Inspect as per print.

NOTE: Job No. J-4-10-4 will be the material used for stud, Job No. J-5-10-5



$\frac{1}{16}$ R
$\frac{3}{4}$
$\frac{7}{8}$
$\frac{5}{8}$
$2\frac{3}{16}$
$2\frac{1}{16}$
$5\frac{1}{2}$
NO. 3 CENTER DRILL - $\frac{3}{16}$ D.
BOTH ENDS

MATERIAL - AISI 1018 C.R.S.

SCALE: 1 = 1 DATE: 12-28-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
IDLER SHAFT		
SHEET 1 OF 1	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ±1/64 DECIMAL DIMENSIONS ±.005 ANGULAR DIMENSIONS ±1/2	DRAWING NUMBER 4-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-5-10-5 Drawing No. 5-10A1

STUD BOLT

EQUIPMENT: Lathe

TOOLS:
lathe dog
file card
bench vise
cutting oil
6" steel rule
vise jaw caps
0-1" micrometer
small "v" block
lathe collet set
1/2"-13 N.C. die and die stock
10" mill file
soft metal vise jaws
left hand toolholder
straight toolholder
right hand facing tool
right hand turning tool

SAFETY PRECAUTIONS:

1. Be careful not to run into lathe dog with turning tool.
2. Observe all shop safety regulations.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

NOTE: Use Idler Shaft from Job No. J-4-10-4 as stock for this job.

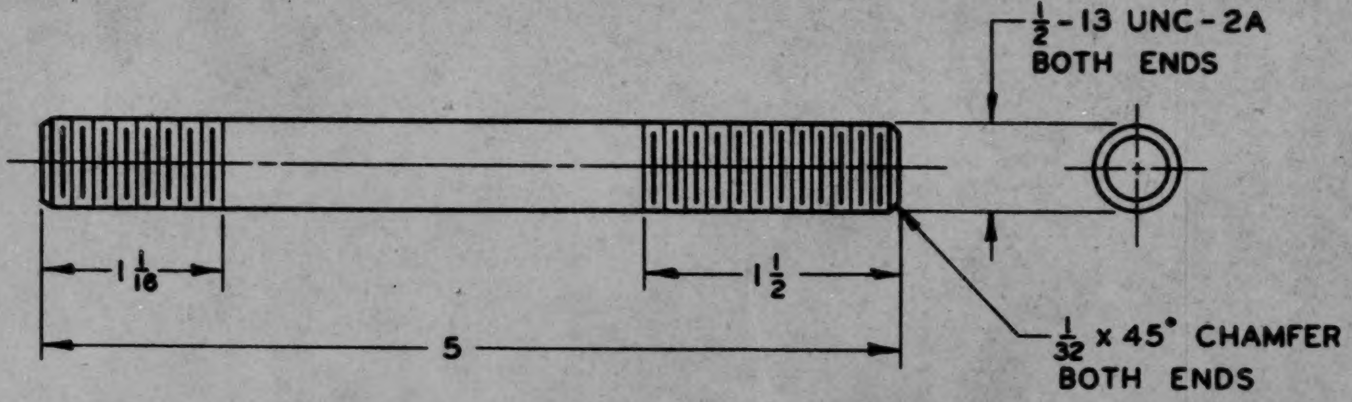
1. Mount work piece between centers.
2. Select proper spindle speed and feed.
3. Turn 1/2" diameter to lathe dog (refer to Operation Sheet No. SL-3-8).
4. Reverse work piece and reposition lathe dog.

NOTE: Use soft metal strip to protect finished diameter from damage.

5. Finish turning 1/2" diameter.
6. Mount work piece in collet (refer to Operation Sheet No. SL-1-16).
7. Remove center by facing end and chamfer 1/32" x 45° as per print (refer to Operation Sheet No. SL-1-17).
8. Reverse work piece; face to length and chamfer 1/32" x 45°.
9. Grip work piece between vise jaw and "v" block, so that it projects about 2" above the vise jaws.

NOTE: Use soft metal jaws to protect work piece and "v" block.

10. Mount 1/2"-13 N.C. die in die stock.
11. Chase 1 1/16" length of thread. Check thread with 1/2"-13 N.C. nut. Use thread cutting oil (refer to Operation Sheet No. SL-3-7).


$\frac{1}{2}$-13 UNC-2A
BOTH ENDS
$1\frac{1}{16}$
$1\frac{1}{2}$
5
$\frac{1}{32}$ x 45° CHAMFER
BOTH ENDS

NOTE: MAKE FROM IDLER SHAFT 4-10A1

MATERIAL - AISI - 1018 C.R.S.

SCALE: 1 = 1
DATE: 12-28-70
APPROVED BY:
DRAWN BY D.G.H
REVISED

STUD BOLT

SHEET 1 OF 1

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
5-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-6-10-6 Drawing No. 6-10A1

CAN PUNCH

EQUIPMENT: Lathe and power cutoff saw.

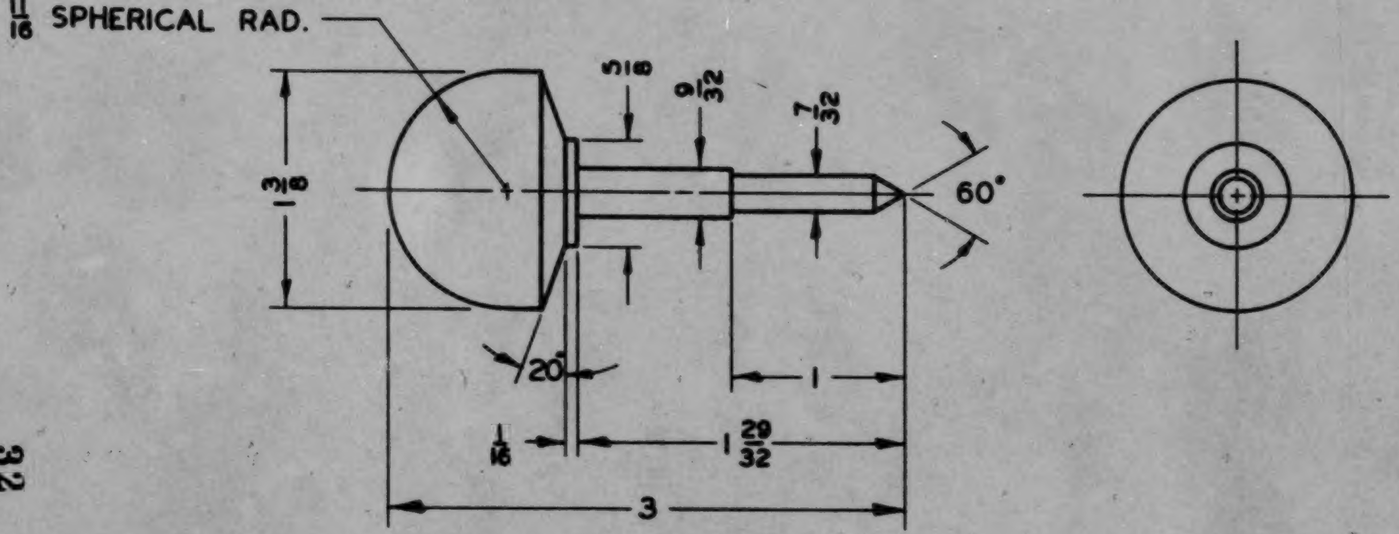
TOOLS:
file card
cutting oil
6" steel rule
abrasive cloth
0-1" micrometer
10" mill file
11/16" radius gauge
left hand toolholder
right hand turning tool
soft metal strips

SAFETY PRECAUTIONS:

1. Check all tools for sharpness.
2. Never use a file without a handle.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select alloy steel and cut to sufficient length on power cutoff saw.
2. Select proper spindle speed and feed.
3. Mount work piece in lathe 3 jaw chuck (extend piece 2-1/16" from face of chuck).
4. Turn 9/32" diameter.
5. Turn 7/32" diameter.
6. Turn taper on point (refer to Operation Sheet No. SL-1-12).
7. Turn 20° angle on face of punch to point where angular surface meets 5/8" diameter offset.
8. Polish with abrasive cloth.
9. Reverse work piece, mount on 9/32" diameter (use soft metal strips for protection of work piece).
10. Face to length as per print.
11. Form 11/16" radius.
12. File radius to eliminate machine marks.
13. Polish with abrasive cloth.
14. Inspect as per print.


11/16 SPHERICAL RAD.
1 3/8
5/8
9/32
7/32
60°
20°
1
1/16
1 29/32
3

MATERIAL - AISI 4140 C.R.S.

SCALE: 1 = 1
DATE: 12-28-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

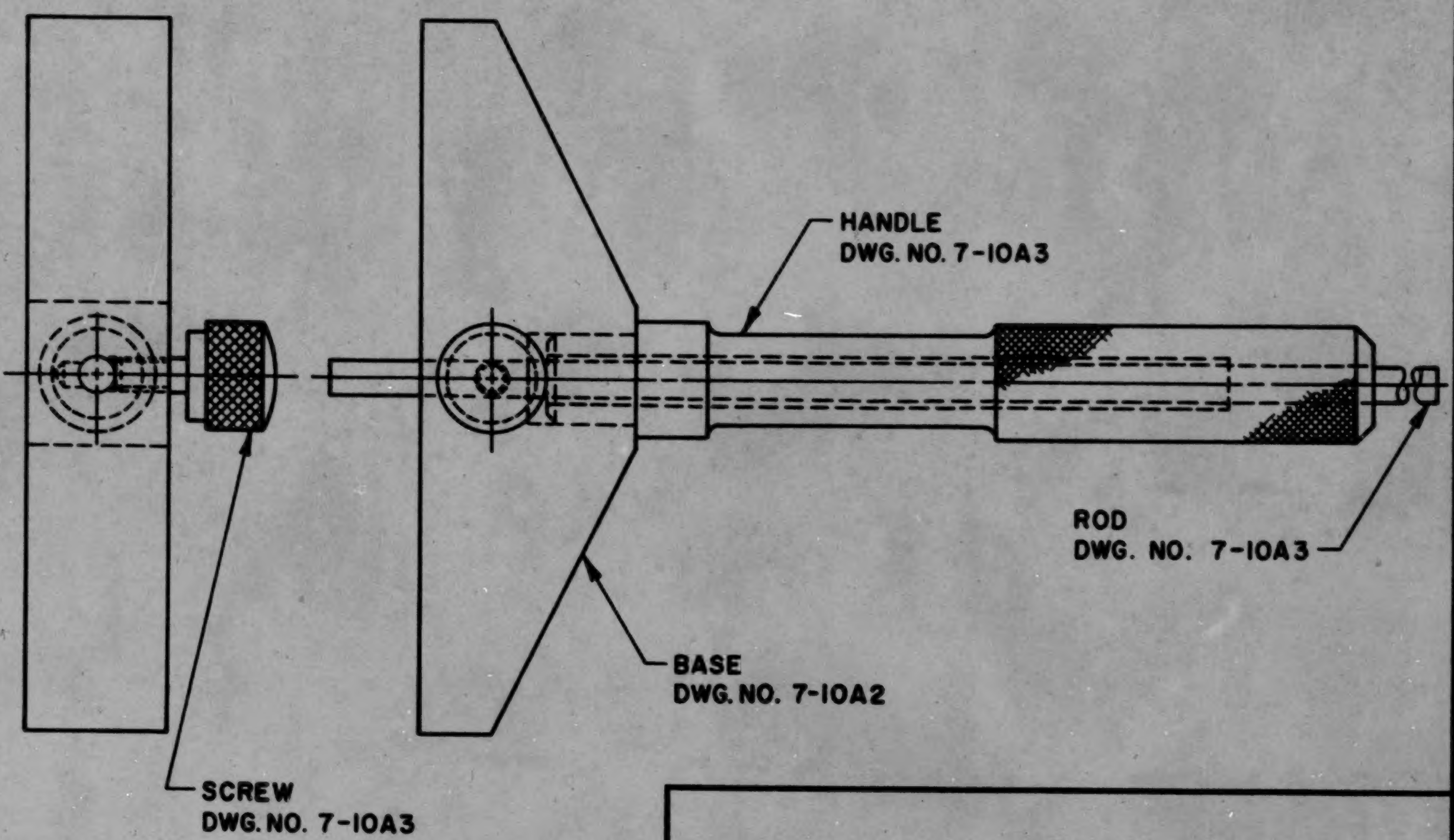
CAN PUNCH

SHEET 1 OF 1

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
6 - 10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY


HANDLE
DWG. NO. 7-10A3
ROD
DWG. NO. 7-10A3
BASE
DWG. NO. 7-10A2
SCREW
DWG. NO. 7-10A3

SCALE: 2" = 1"
DATE: 8-5-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

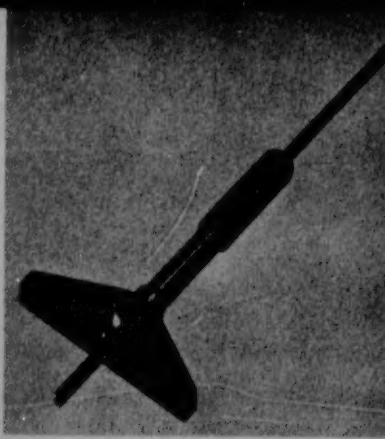
DEPTH GAGE - ASSEMBLY

SHEET 1 OF 3

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2

DRAWING NUMBER
7-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



JOB SHEET

Job No. J-7-10-7 Drawing No. 7-10A2

DEPTH GAUGE - BASE

EQUIPMENT: Vertical milling machine, drill press, surface grinder and power cutoff saw.

TOOLS:
scriber
file card
layout dye
7/64" drill
prick punch
cutting oil
center punch
19/64" drill
surface gauge
layout hammer
19/64" square bottom drill
#36 drill (.1065)
6-32 N.C. tap set
10" mill file
T-handle tap wrench
1/8" machine reamer
5/16" machine reamer
combination square set

SAFETY PRECAUTIONS:

1. Keep hands away from moving parts, cutters, tools and grinding wheels.
2. Clamp all work securely while machining.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

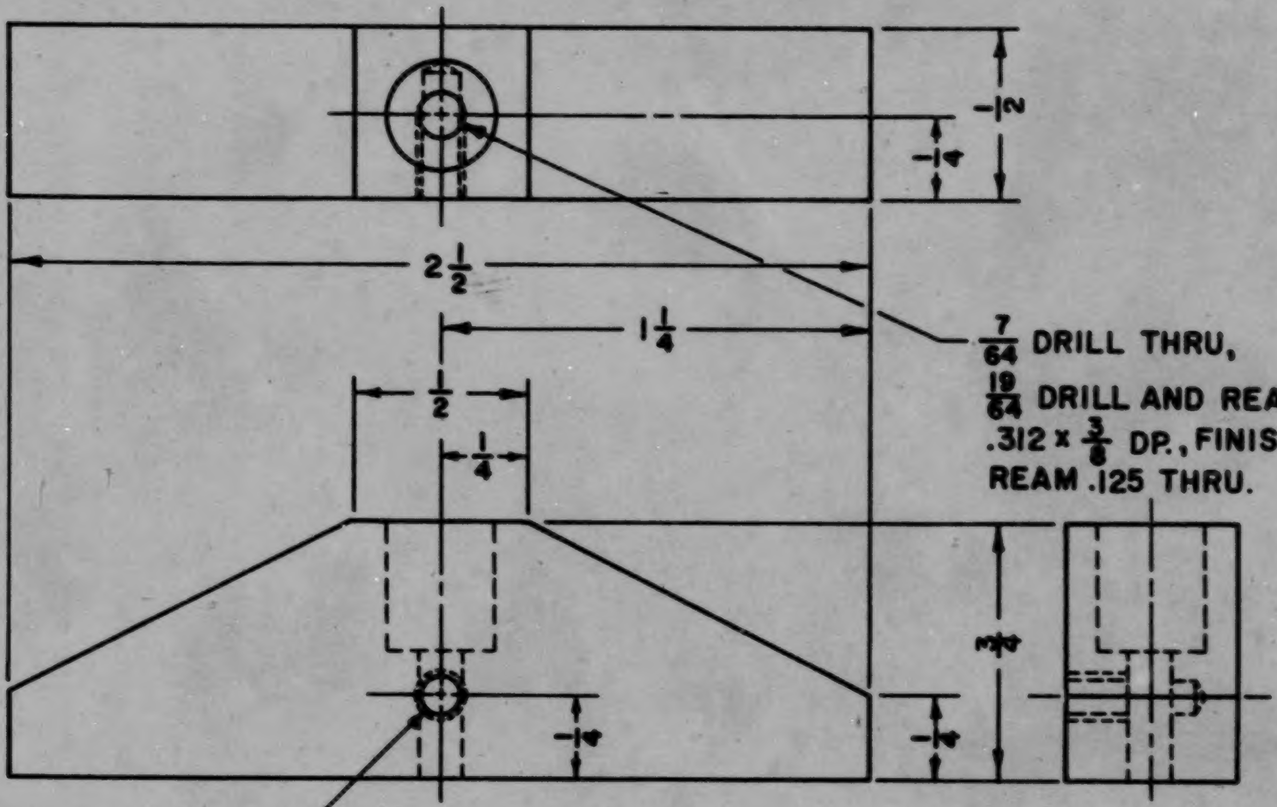
PROCEDURE:

1. Select material and cut to rough length on power cutoff saw
2. Square off ends either by filing or milling (refer to Operation Sheet Nos. SL-4-1, 2, 8, 9, 10, 11, and 12).
3. Layout 1/2" wide dimension.
4. Mount work piece in milling machine vise.
5. Select proper speed and feed and mill to layout line (refer to Operation Sheet No. SL-4-14).
6. Layout angles.
7. Remount work piece in milling machine vise.
8. Use surface gauge to set layout lines parallel to machine table.
9. Mill both angles to both layout lines.
10. Remove all burrs.
11. Layout location of 5/16" reamed hole as per print.
12. Layout location of 6-32 N.C. tapped hole as per print.
13. Drill 7/64" hole through work piece using drill press.

14. Drill 19/64" counterbored hole.

    NOTE: Use an adequate supply of cutting oil when drilling, reaming, and tapping.

15. Ream 5/16" hole - 3/8" deep (refer to Operation Sheet No. SL-6-2).
16. Ream 7/64" hole with 1/8" machine reamer.
17. Drill #36 hole for 6-32 N.C. thread.
18. Tap 6-32 N.C.
19. Remove all burrs as per print.
20. Mount work piece on surface grinder (refer to Operation Sheet Nos. SL-7-1, 2, 3, 4, and 5).
21. Grind all flat surfaces.
22. Remove all burrs left after surface grinding.
23. Inspect as per print.


$\frac{1}{2}$
$\frac{1}{4}$
$2\frac{1}{2}$
$1\frac{1}{4}$
$\frac{1}{2}$
$\frac{1}{4}$
$\frac{1}{4}$
$\frac{3}{4}$
$\frac{1}{4}$

$\frac{7}{64}$ DRILL THRU,
$\frac{19}{64}$ DRILL AND REAM–
.312 x $\frac{3}{8}$ DP., FINISH
REAM .125 THRU.

NO. 35(.110) DRILL – $\frac{3}{8}$ DP.
6–32 UNC–2B – $\frac{1}{4}$ DP.

MATERIAL – AISI - 1018 C.R.S.

SCALE: 2" = 1" DATE: 8-8-70	APPROVED BY:	DRAWN BY D. G. H. REVISED
DEPTH GAGE		
SHEET 2 OF 3	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1 2	DRAWING NUMBER 7-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-7-10-8

Drawing No. 7-10A3

DEPTH GAUGE - HANDLE

EQUIPMENT: Lathe and power cutoff saw.

TOOLS:
- file card
- lathe dog
- cutting oil
- 7/64" drill
- 3/16" drill
- 6" steel rule
- knurling tool
- #4 center drill
- 0-1" micrometer
- lathe collet set
- 10" mill file
- 1/8" machine reamer
- left hand toolholder
- right hand facing tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle
- right hand turning tool

SAFETY PRECAUTIONS:

1. Be careful not to run the tool into the lathe dog.
2. Observe all shop safety rules.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select material and cut to rough length on power cutoff saw.
2. Remove all burrs.
3. Select proper spindle speed and feed.
4. Mount work piece in collet, face and center drill first end.
5. Drill 3/16" hole (refer to Operation Sheet No. SL-1-18).
6. Reverse work piece in collet, face to length and center drill.
7. Drill 7/64" hole.
8. Ream hole (reduce speed 1/3 and use cutting oil - refer to Operation Sheet No. SL-1-20).
9. Mount work piece between centers with 1/8" hole in tailstock center, 3/16" hole in headstock center.
10. Turn O.D. to 13/32" diameter and length as specified.
11. Knurl 13/32" diameter as per print (refer to Operation Sheet No. SL-1-10).
12. Turn 5/16" diameter as per print.
13. Chamfer knurled end as per print.
14. Reverse piece between centers and protect knurled surface from damage with copper strip.
15. Machine diameter for press fit. Read print carefully. Note Tolerance!
16. Chamfer end as per print.
17. Remove all burrs.
18. Inspect as per print.

JOB SHEET

Job No. J-7-10-9 Drawing No. 7-10A3

DEPTH GAUGE - SCREW

EQUIPMENT: Lathe

TOOLS:
file card
cutting oil
hand hacksaw
6" steel rule
knurling tool
6-32 N.C. die and die stock
abrasive cloth
0-1" micrometer
lathe collet set
10" mill file
left hand toolholder
right hand turning tool

SAFETY PRECAUTIONS:

1. Always wear eye protection.
2. Observe all safety rules.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select C.R. steel as per print, material should be long enough to make screw in one position.
2. Mount stock in lathe collet, extend material 1" out from face of collet.
3. Turn 5/16" diameter to length as per print.
4. Turn thread diameter and chamfer 30° to thread depth.
5. Chase thread with 6-32 N.C. die and die stock and check fit with tapped hole in base.
6. Knurl 3/8" diameter as per print.
7. Cut off work piece with hand hacksaw.
8. Mount knurled head in 3/8" collet and face to length.
9. File 3/8" radius.
10. Polish with abrasive cloth.
11. Remove all burrs.
12. Inspect as per print.

JOB SHEET

Job No. J-7-10-10 Drawing No. 7-10A3

DEPTH GAUGE - ROD

EQUIPMENT: Lathe

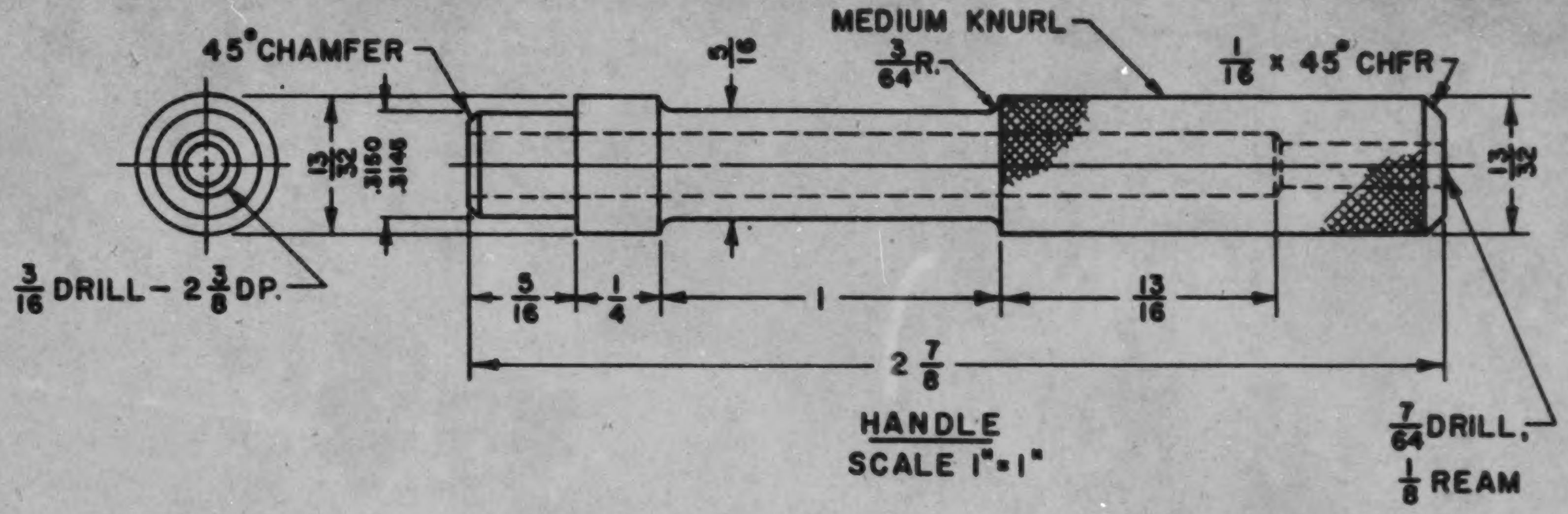
TOOLS: file card
cutting oil
hand hacksaw
abrasive cloth
lathe collet set
10" mill file

SAFETY PRECAUTIONS:

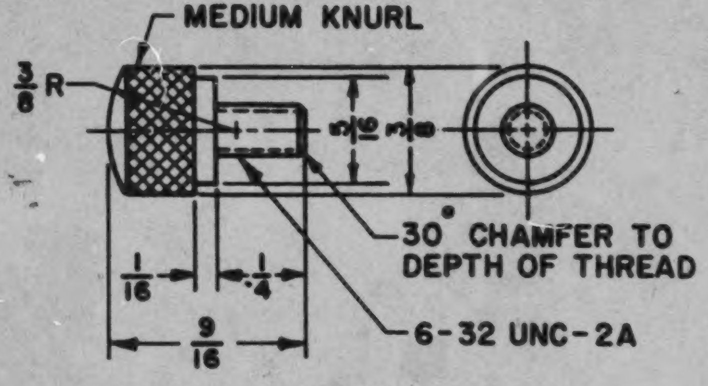
1. Observe all shop safety rules.
2. Practice filing left handed.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

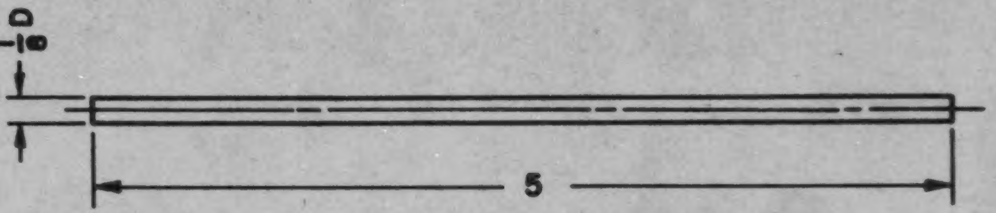
1. Select drill rod and cut to length with hand hacksaw.
2. Mount work piece in lathe collet.
3. Remove all burrs from first end.
4. Polish end with abrasive cloth.
5. Reverse work piece in collet.
6. Remove all burrs.
7. Polish end with abrasive cloth.
8. Inspect as per print.


45° CHAMFER
$\frac{13}{32}$
.3150
.3145
$\frac{3}{16}$ DRILL - 2 $\frac{3}{8}$ DP.
$\frac{5}{16}$
MEDIUM KNURL
$\frac{3}{64}$ R.
$\frac{1}{16}$ x 45° CHFR
$\frac{13}{32}$
$\frac{5}{16}$
$\frac{1}{4}$
1
$\frac{13}{16}$
2 $\frac{7}{8}$
$\frac{7}{64}$ DRILL,
$\frac{1}{8}$ REAM

HANDLE
SCALE 1" = 1"


MEDIUM KNURL
$\frac{3}{8}$ R
$\frac{5}{16}$
$\frac{3}{8}$
30° CHAMFER TO DEPTH OF THREAD
6-32 UNC-2A
$\frac{1}{16}$
$\frac{1}{4}$
$\frac{9}{16}$

SCREW
SCALE 1" = 1"

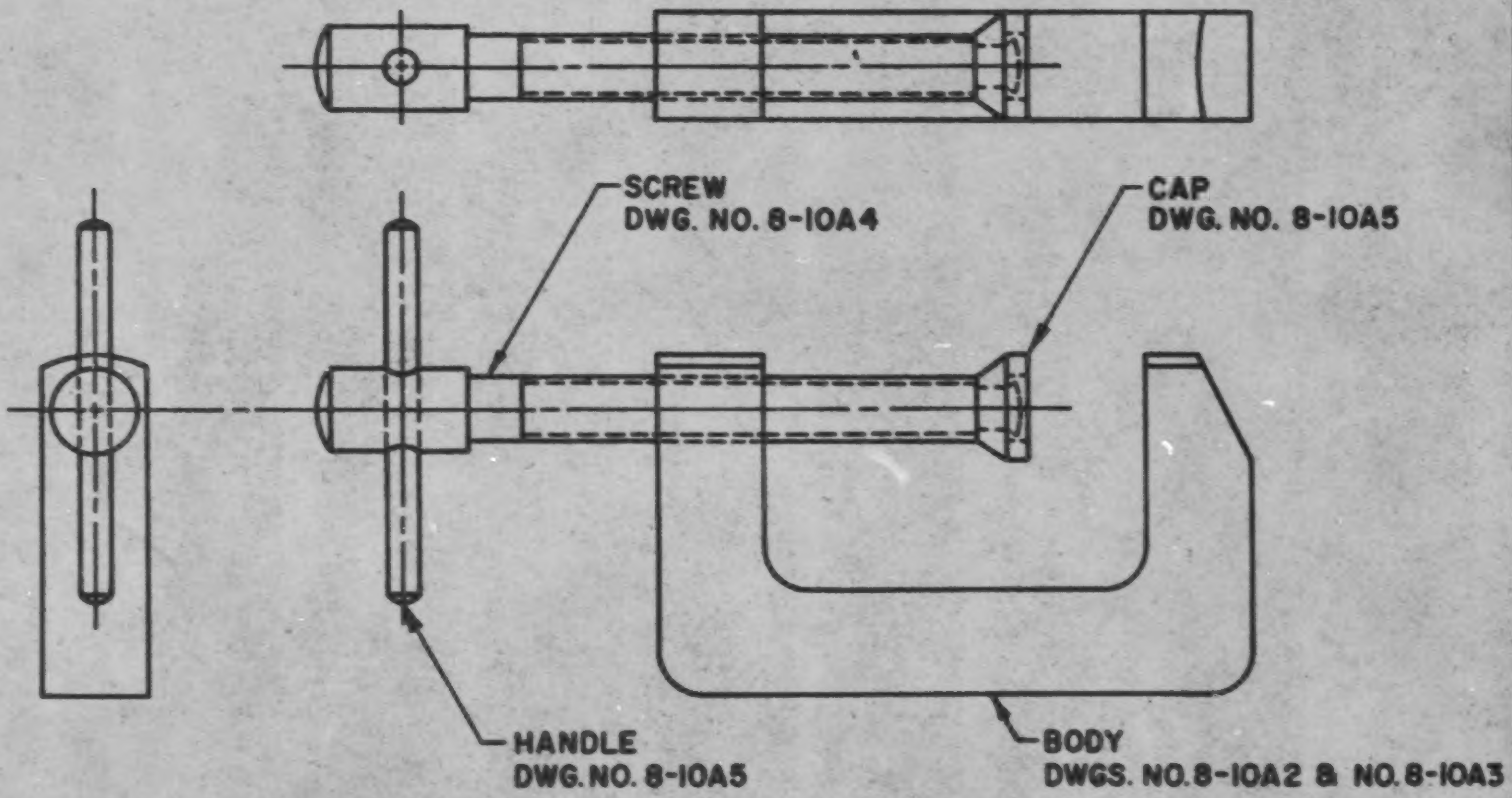


ROD
SCALE 1" = 1"

MATERIAL -HANDLE-AISI-1018 C.R.S.
-SCREW-AISI-1018 C.R.S.
-ROD-DRILL ROD-AISI TYPE 02

SCALE: AS SHOWN DATE: 8-10-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
DEPTH GAGE - DETAILS		
SHEET 3 OF 3	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1 2	DRAWING NUMBER 7-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY


SCREW
DWG. NO. 8-10A4
CAP
DWG. NO. 8-10A5
HANDLE
DWG. NO. 8-10A5
BODY
DWGS. NO. 8-10A2 & NO. 8-10A3

SCALE: 1" = 1" DATE: 8-3-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
C-CLAMP-ASSEMBLY		
SHEET 1 OF 5	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1 2	DRAWING NUMBER 8-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-8-10-11

Drawing Nos. 8-10A2
and 8-10A3

C-CLAMP - BODY

EQUIPMENT: Power cutoff saw, drill press, and vertical milling machine.

TOOLS:
scriber
file card
1/2" drill
layout dye
prick punch
3" dividers
3/16" drill
5/16" drill
center punch
layout hammer
hand hacksaw
6" steel rule
center finder
abrasive cloth
#3 center drill
combination square
10" mill file
3/8" - N.C. tap set
adjustable tap wrench
10" flat file
cutting oil

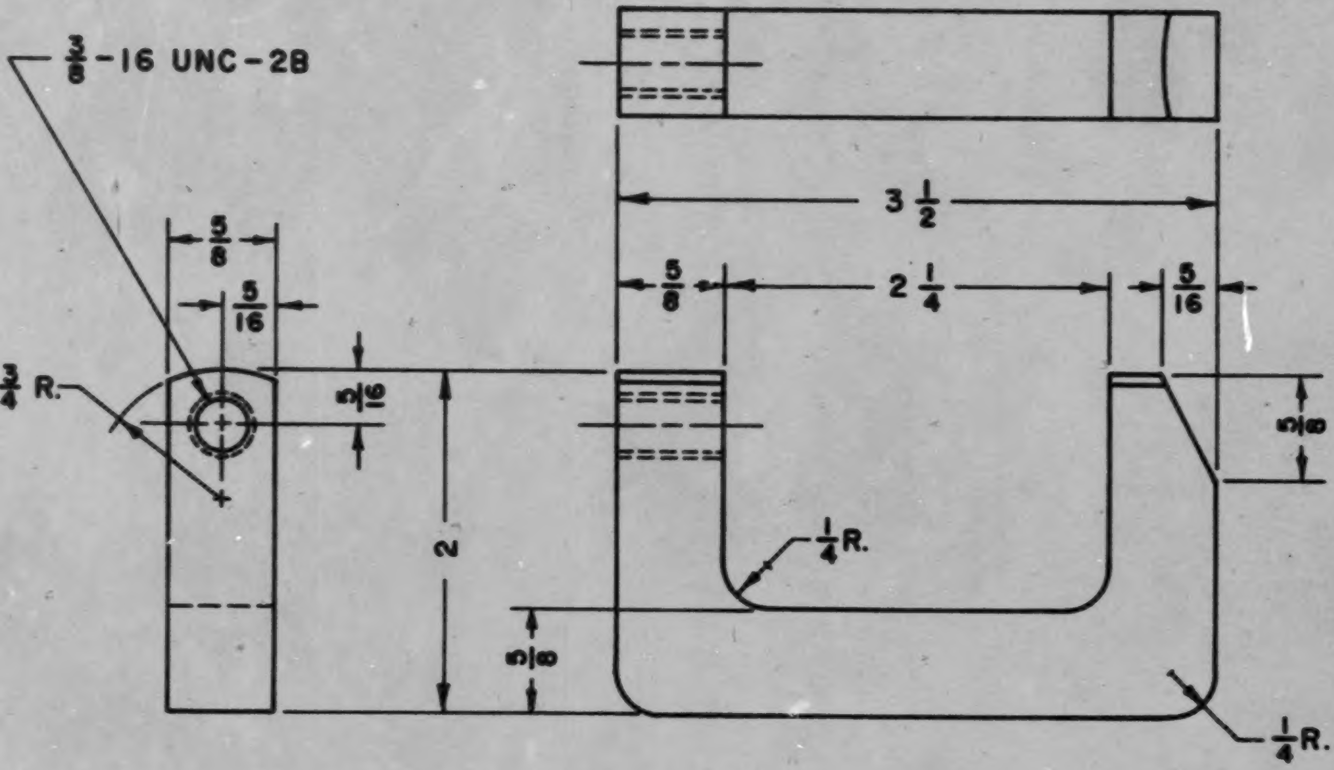
SAFETY PRECAUTIONS:

1. Always clamp job securely in vise before drilling.
2. Do not wear loose clothing near revolving spindles, drills, or gears.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select C.R. steel and cut to rough length on power cutoff saw.
2. Mount work piece on milling machine.
3. Machine ends square and to length as per print.
4. Layout finish lines on clamp body as per print 8-10A2.
5. Layout, prick punch, and center punch for 1/2" holes to produce 1/4" radii on inside section of clamp body as per print 8-10A3.
6. Layout, prick punch, and center punch for a series of 3/16" holes to facilitate removal, by hand hacksaw, of excess stock on inside section of clamp body as per print 8-10A3.
7. Drill holes as per print using drill press.
8. Transfer work piece to bench vise and use hand hacksaw to remove excess stock.
9. File inside section to layout lines.
10. Saw corner of jaw according to print using hand hacksaw.
11. File outline of jaw body to layout lines paying particular attention to the angle on the jaw and the 1/4" radii on the outside corners of the jaw body.

12. Layout, prick punch, and center punch location for tapped hole.
13. Position in drill press vise and locate center of hole with center finder.
14. Center drill to mark starting location for threaded hole.
15. Drill 5/16" hole.
16. Tap hole using center point in drill chuck to ensure proper alignment of tap.
17. Remove all burrs.
18. Draw file all over.
19. Polish with abrasive cloth.
20. Inspect as per print.



3/8-16 UNC-2B
5/8
5/16
3/4 R.
5/16
2
5/8
3 1/2
5/8
2 1/4
5/16
5/8
1/4 R.
1/4 R.

NOTES:

1. SEE DWG. NO. 8-10A3 FOR LAYOUT OF
INSIDE OPENING.
2. BREAK ALL SHARP EDGES.

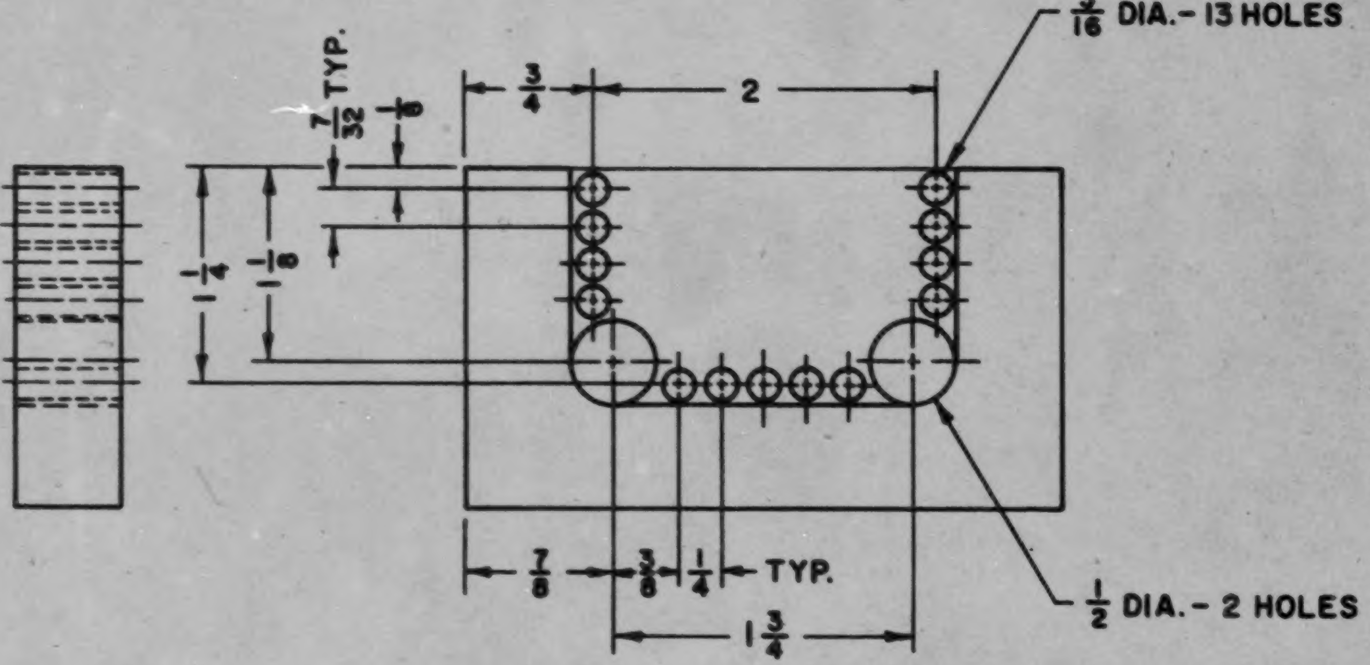
MATERIAL — AISI — 1018 C.R.S.

SCALE: 1" = 1"
DATE: 7-10-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

C-CLAMP - BODY

SHEET 2 OF 5
UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ±1/64
DECIMAL DIMENSIONS ±.005
ANGULAR DIMENSIONS ±1 2
DRAWING NUMBER
8-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY


$\frac{3}{16}$ DIA.- 13 HOLES
$\frac{1}{2}$ DIA.- 2 HOLES
$\frac{7}{32}$ TYP.
$\frac{1}{8}$
$\frac{3}{4}$
2
$1\frac{1}{4}$
$1\frac{1}{8}$
$\frac{7}{8}$
$\frac{3}{8}$
$\frac{1}{4}$
TYP.
$1\frac{3}{4}$

SCALE: 1" = 1" DATE: 8-3-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
C-CLAMP- BODY LAYOUT		
SHEET 3 OF 5	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ±1/64 DECIMAL DIMENSIONS ±.005 ANGULAR DIMENSIONS ±1/2	DRAWING NUMBER 8-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-8-10-12

Drawing No. 8-10A4

C-CLAMP - SCREW

EQUIPMENT: Lathe, drill press, and power cutoff saw.

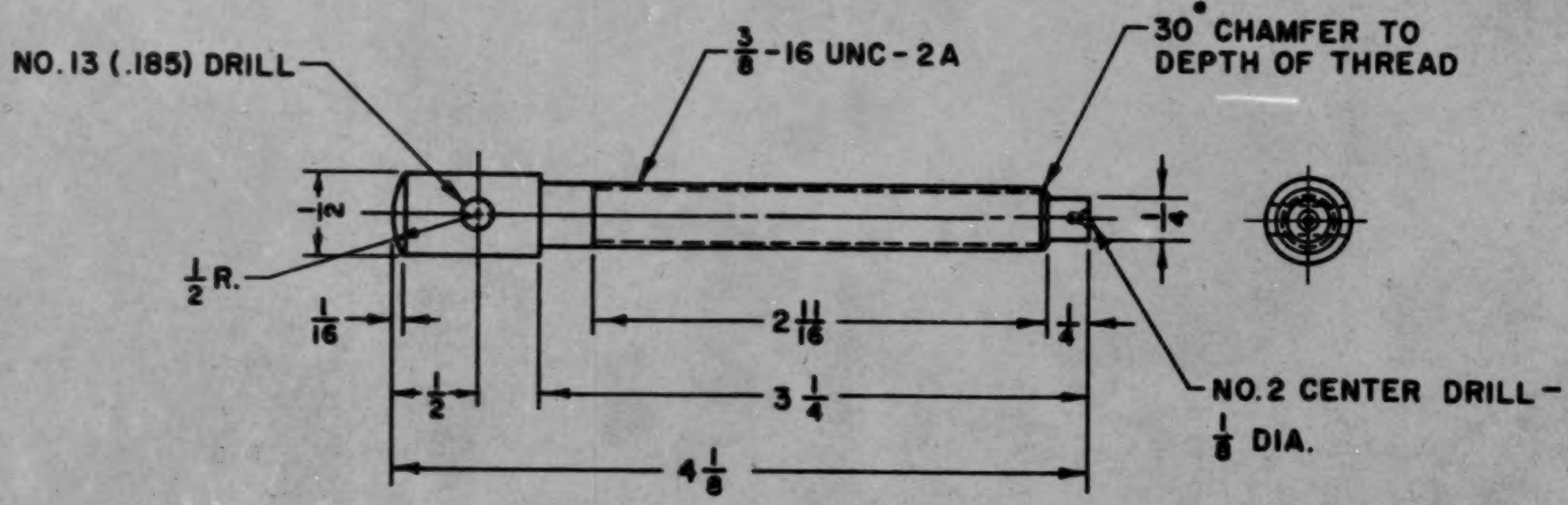
TOOLS:
- scriber
- file card
- cutting oil
- center gauge
- screw-pitch gauge
- 6" steel rule
- abrasive cloth
- layout dye
- #1 center drill
- 0-1" micrometer
- #13 drill (.185)
- 60° threading tool
- 10" mill file
- lathe collet set
- layout hammer
- prick punch
- straight toolholder
- right hand facing tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle
- right hand turning tool
- center punch

SAFETY PRECAUTIONS:

1. Loose clothing apparel is dangerous around moving machinery.
2. Observe all shop safety rules.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select round C.R. steel.
2. Cut stock to rough length on power cutoff saw.
3. Mount stock in lathe collet and face both ends, finish to length as per print.
4. Center drill one end.
5. Turn 3/8" diameter as per print.
6. Set up lathe for threading (refer to Operation Sheet No. SL-1-11).
7. Chase 3/8" - 16 N.C. threads as per print.
8. Check thread fit with tapped hole in clamp body.
9. Turn 1/4" diameter and chamfer 30° to thread depth.
10. Reverse work piece in collet.
11. File rounded face on large diameter.
12. Layout and drill #13 hole.
13. Remove all burrs.
14. Polish rounded end and large diameter with abrasive cloth.
15. Inspect as per print.


NO. 13 (.185) DRILL
$\frac{3}{8}$-16 UNC-2A
30° CHAMFER TO DEPTH OF THREAD
$\frac{1}{2}$
$\frac{1}{2}$ R.
$\frac{1}{16}$
$2\frac{11}{16}$
$\frac{1}{4}$
$\frac{1}{4}$
$\frac{1}{2}$
$3\frac{1}{4}$
NO. 2 CENTER DRILL - $\frac{1}{8}$ DIA.
$4\frac{1}{8}$

MATERIAL - AISI-1018 C.R.S.

SCALE: 1" = 1" DATE: 7-11-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
C-CLAMP-SCREW		
SHEET 4 OF 5	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1 2	DRAWING NUMBER 8-10A4

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-8-10-13

Drawing No. 8-10A5

C-CLAMP - SCREW CAP

EQUIPMENT: Lathe

TOOLS:

- file card
- 1/4" drill
- cutting oil
- 6" steel rule
- parting blade and holder
- abrasive cloth
- #4 center drill
- 3/8" counterbore
- lathe collet set
- 10" mill file
- straight toolholder
- right hand facing tool
- left hand toolholder
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle
- right hand turning tool

SAFETY PRECAUTIONS:

1. Remove cutting tools from lathe toolholders before performing other operations.
2. Check all dimensions carefully to limit material loss.
3. Operate no equipment without authority to do so.

PROCEDURE:

1. Select round C.R. steel.
2. Mount in collet and face one end.
3. Center drill end.
4. Drill 1/4" hole about 1/2" deep.
5. Counterbore 5/16" diameter.
6. Set compound at 34° with center line so that small end of taper is at headstock end of lathe.
7. Turn angle as per print.
8. Remove all burrs.
9. Polish with abrasive cloth.
10. Part off to length (refer to Operation Sheet No. SL-1-22).
11. Remove burrs caused by parting.
12. Inspect as per print.

JOB SHEET

Job No. J-8-10-14 Drawing No. 8-10A5

C-CLAMP - HANDLE

EQUIPMENT: Lathe

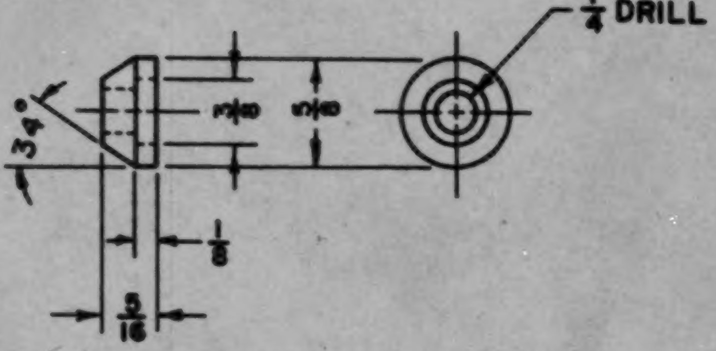
TOOLS:
file card
cutting oil
hand hacksaw
6" steel rule
abrasive cloth
lathe collet set
10" mill file

SAFETY PRECAUTIONS:

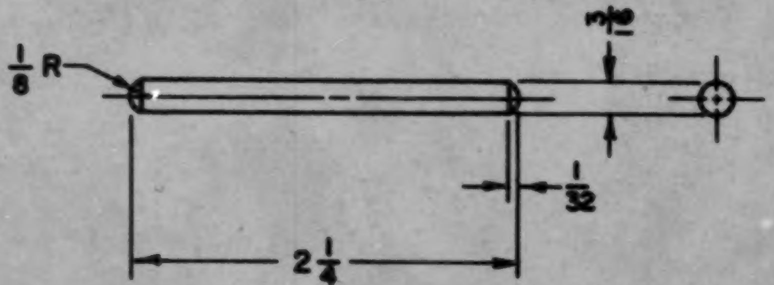
1. Never use a file without a handle.
2. Check all dimensions carefully to limit material loss.
3. Operate no equipment without authority to do so.

PROCEDURE:

1. Select round C.R. steel as per print.
2. Cut to length using hand hacksaw.
3. Mount work piece in lathe collet and form radii on ends using file.
4. Polish with abrasive cloth.
5. Inspect as per print.



CAP



HANDLE

MATERIAL - AISI-1018 C.R.S.

SCALE: 1" = 1" DATE: 7-11-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
C-CLAMP-DETAILS		
SHEET 5 OF 5	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2	DRAWING NUMBER 8-10A5

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-9-10-15 Drawing No. 9-10A1

DRILL GRINDING GAUGE

EQUIPMENT: Bench vise, drill press, and horizontal milling machine.

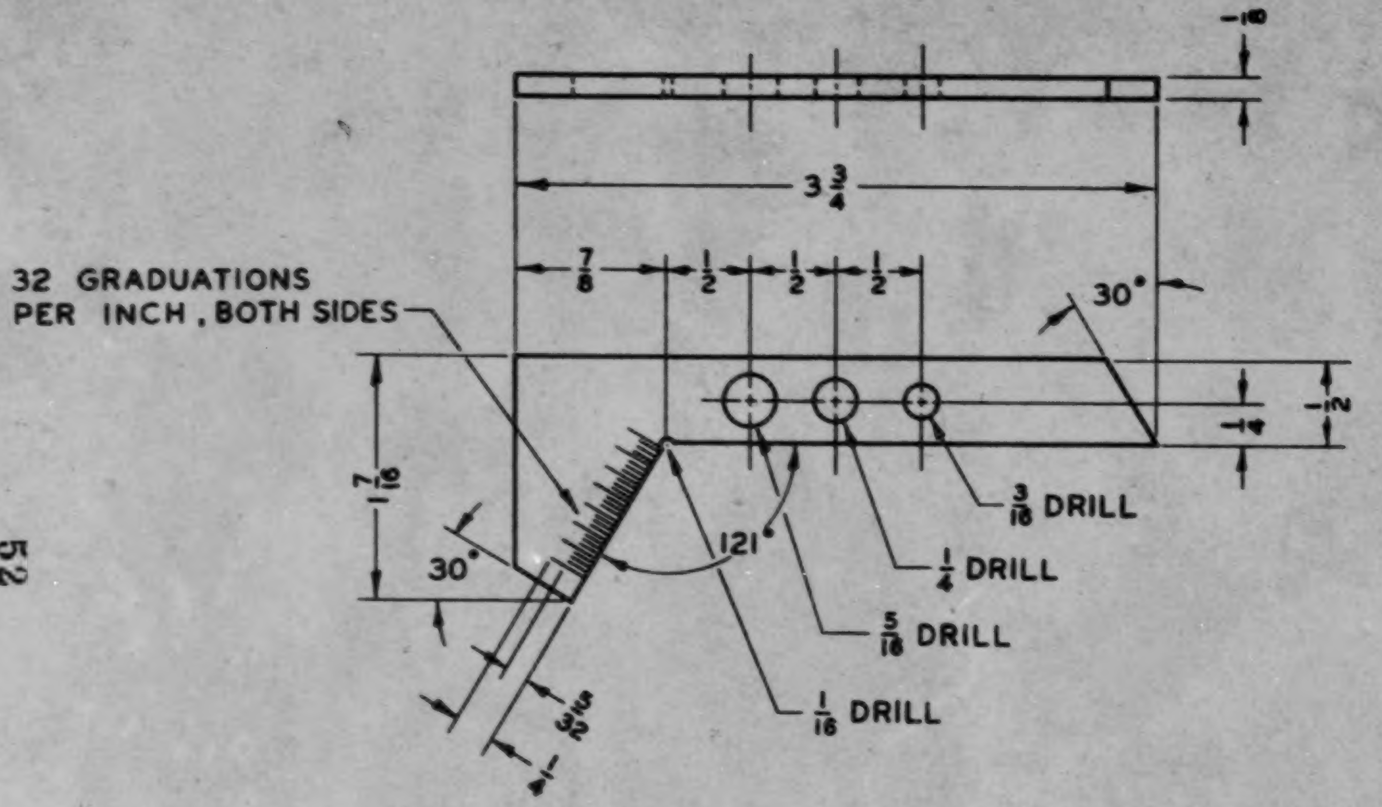
TOOLS:
- scriber
- file card
- layout dye
- protractor
- 1/4" drill
- prick punch
- 3" dividers
- cutting oil
- 1/16" drill
- 3/16" drill
- 5/16" drill
- center punch
- hand hacksaw
- 6" steel rule
- abrasive cloth
- 0-1" micrometer
- ball peen hammer
- combination square
- 10" mill file

SAFETY PRECAUTIONS:

1. Observe all shop safety rules.
2. Check all dimensions carefully to limit material loss.
3. Operate no equipment without authority to do so.
4. Fasten all work securely when drilling holes.

PROCEDURE:

1. Select stock and saw to length as per print.
2. File both ends square and remove all burrs.
3. Layout as per print.
4. Prick punch centers for drilling. Check for accuracy, then use center punch.
5. Drill all holes, being careful to follow layout lines.
6. Saw to within 1/32" of layout lines using hand hacksaw.
7. File to layout lines constantly checking 1/2" dimension with outside micrometer.
8. Graduate both sides in 1/32" spacings on milling machine (refer to Operation Sheet No. SL-4-4).
9. Draw file to a smooth finish.
10. Polish with abrasive cloth.
11. Inspect as per print.



1/16
3 3/4
7/8
1/2
1/2
1/2
30°
32 GRADUATIONS PER INCH, BOTH SIDES
1 7/16
1/2
1/4
3/16 DRILL
1/4 DRILL
121°
30°
5/16 DRILL
5/32
1/4
1/16 DRILL

MATERIAL- AISI 1018 C.R.S.

SCALE: 1 = 1
DATE: 12-29-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

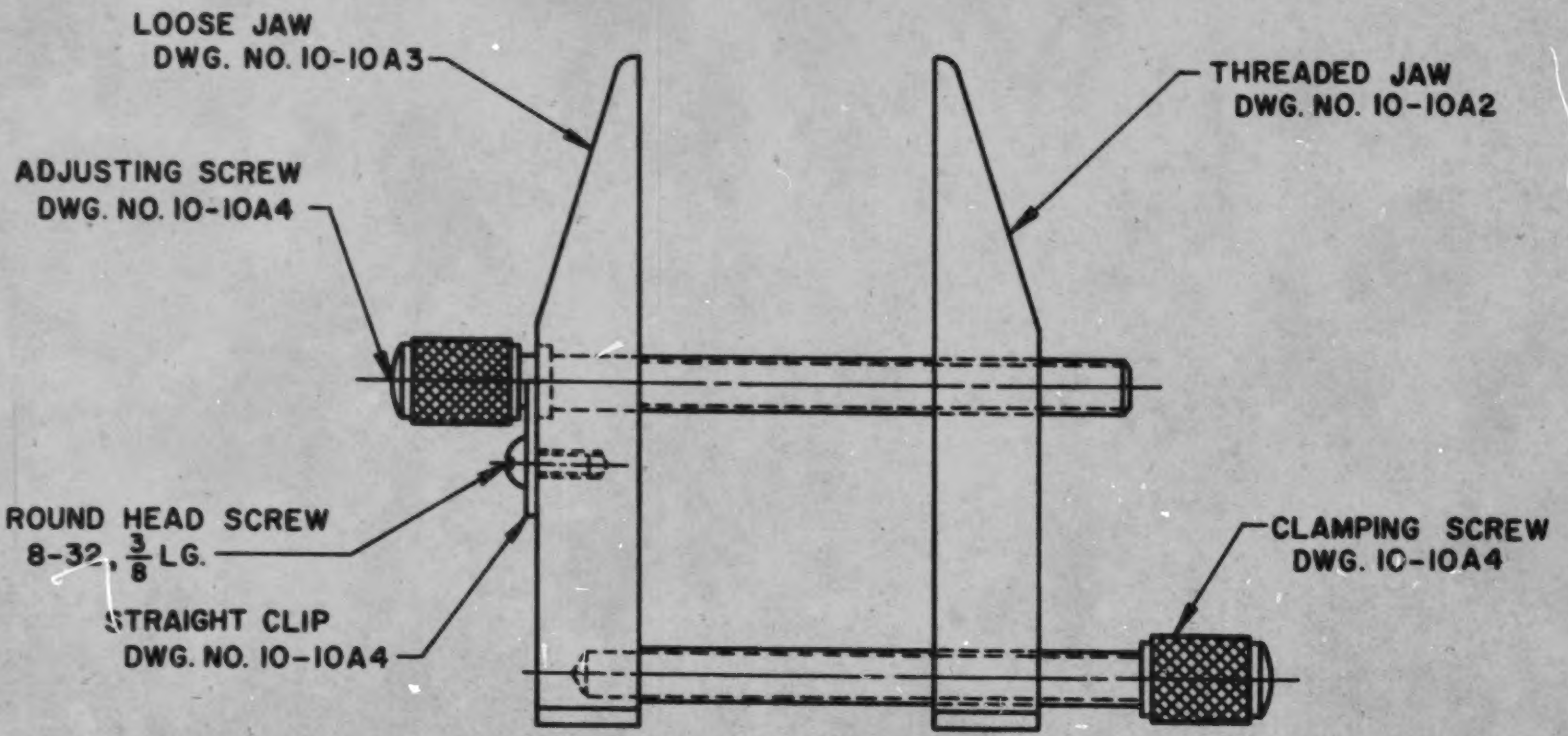
DRILL GRINDING GAGE

SHEET 1 OF 1

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
9-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

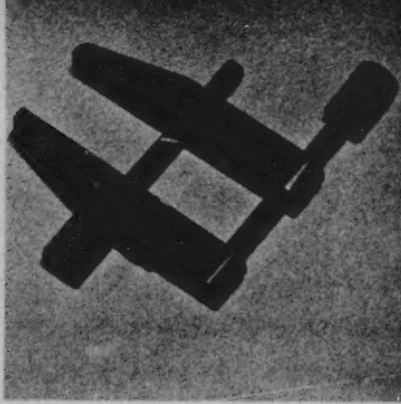

LOOSE JAW
DWG. NO. 10-10A3
THREADED JAW
DWG. NO. 10-10A2
ADJUSTING SCREW
DWG. NO. 10-10A4
ROUND HEAD SCREW
8-32, $\frac{3}{8}$ LG.
STRAIGHT CLIP
DWG. NO. 10-10A4
CLAMPING SCREW
DWG. 10-10A4

SCALE: 1" = 1"
DATE: 9-26-70
APPROVED BY:
DRAWN BY D. G. H.
REVISED

PARALLEL CLAMP-ASSEMBLY

SHEET 1 OF 4
UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ±1/64
DECIMAL DIMENSIONS ±.006
ANGULAR DIMENSIONS ±1 2
DRAWING NUMBER
10-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



JOB SHEET

Job No. J-10-10-16 Drawing No. 10-10A2

PARALLEL CLAMP - THREADED JAW

EQUIPMENT: Power cutoff saw, horizontal milling machine, drill press and heat treating furnace.

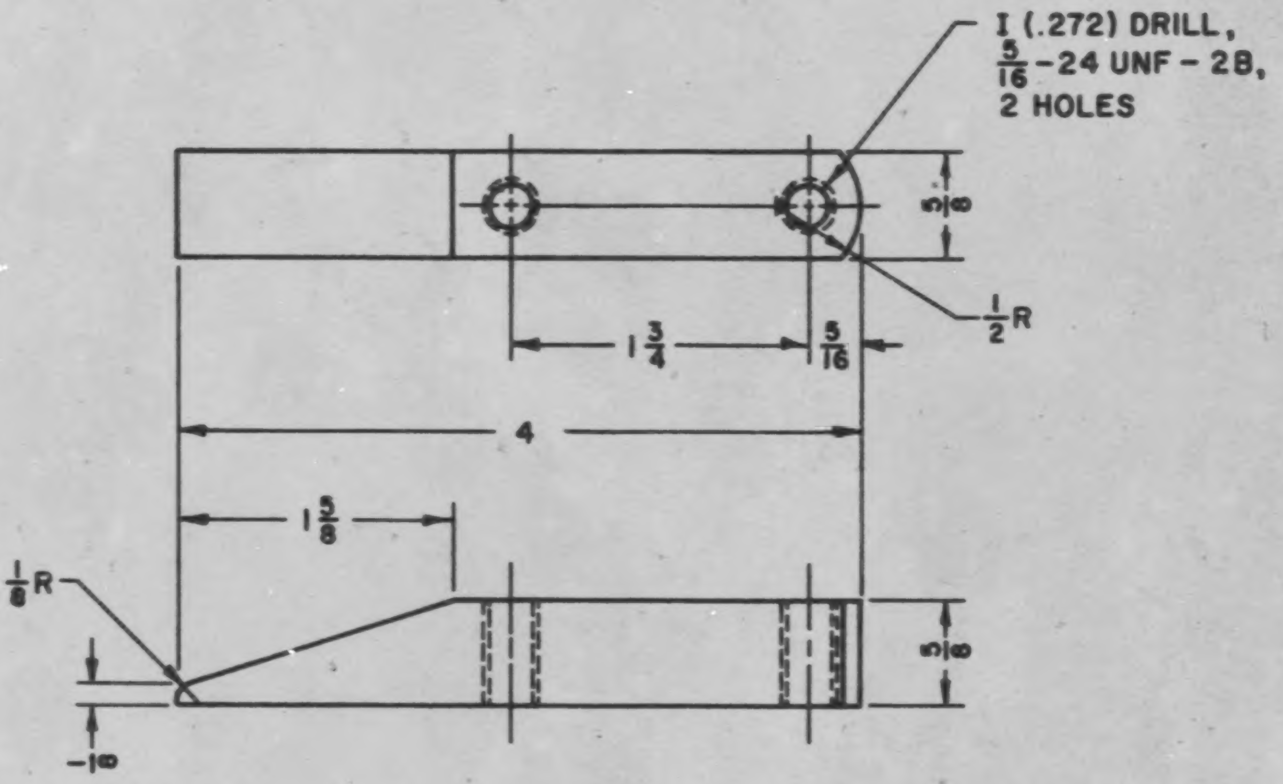
TOOLS:
tongs
scriber
file card
layout dye
prick punch
cutting oil
3" dividers
center punch
hand hacksaw
6" steel rule
layout hammer
abrasive cloth
asbestos gloves
"I" drill (.272)
combination square
10" mill file
adjustable tap wrench
5/16"-24 N.F. tap set
case hardening compound

SAFETY PRECAUTIONS:

1. Never leave a machine unattended while it is in operation.
2. Always report all accidents.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select material and cut to rough length on power cutoff saw.
2. Mount work piece on milling machine.
3. Square both ends and finish to required length.
4. Layout and mill angle.
5. Layout jaw for tapped holes.
6. Drill jaw for tapping, two holes required.
7. Tap two holes.
8. File radius at end of angle.
9. File radius at square end of jaw.
10. Draw file all over.
11. Polish with abrasive cloth.
12. Case harden.
13. Repolish with abrasive cloth.
14. Inspect as per print.


I (.272) DRILL,
$\frac{5}{16}$-24 UNF - 2B,
2 HOLES
$\frac{5}{8}$
$\frac{1}{2}$R
$1\frac{3}{4}$
$\frac{5}{16}$
4
$1\frac{5}{8}$
$\frac{1}{8}$R
$\frac{5}{8}$
$\frac{1}{8}$

MATERIAL - AISI 1018 C.R.S.
HEAT TREATMENT - CASE HARDEN

SCALE: 1" = 1" DATE: 9-19-70	APPROVED BY:	DRAWN BY D. G. H. REVISED
PARALLEL CLAMP - THREADED JAW		
SHEET 2 OF 4	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1 2	DRAWING NUMBER 10-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-10-10-17

Drawing No. 10-10A3

PARALLEL CLAMP - LOOSE JAW

EQUIPMENT: Power cutoff saw, milling machine, drill press, and heat treating furnace.

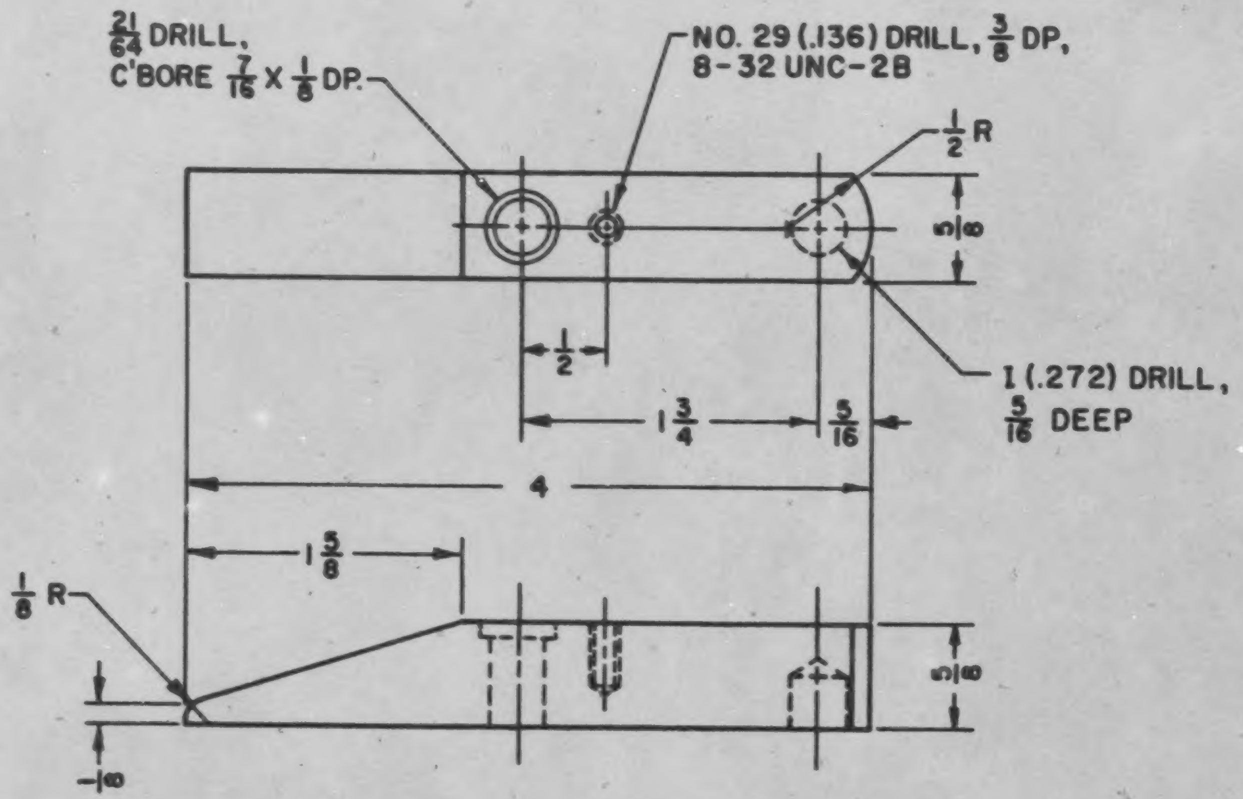
TOOLS:
tongs
scriber
file card
layout dye
cutting oil
prick punch
3" dividers
21/64" drill
center punch
layout hammer
abrasive cloth
asbestos gloves
"I" drill (.272)
case hardening compound
#28 drill (.1405)
8-32 N.F. tap set
7/16" counterbore
combination square
10" mill file
T-handle tap wrench

SAFETY PRECAUTIONS:

1. Secure work by clamp or vise. Never hold with hands.
2. Never attempt measurements while machine is in motion.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select material and cut to rough length on power cutoff saw.
2. Mount work piece on milling machine.
3. Square both ends and finish to required length.
4. Layout and machine angle as per print.
5. Layout holes as per print.
6. Drill 21/64" hole and counterbore as per print.
7. Drill and tap 8-32 N.F. hole for clip.
8. Drill blind hole on opposite side from counterbore as per print.
9. File radius at end of angle.
10. File radius at square end of jaw.
11. Draw file all over.
12. Polish with abrasive cloth.
13. Case harden.
14. Repolish with abrasive cloth.
15. Inspect as per print.


21/64 DRILL,
C'BORE 7/16 X 1/8 DP.
NO. 29 (.136) DRILL, 3/8 DP,
8-32 UNC-2B
1/2 R
5/8
1/2
I (.272) DRILL,
5/16 DEEP
1 3/4
5/16
4
1 5/8
1/8 R
5/8
1/8

MATERIAL - AISI 1018 C.R.S.
HEAT TREATMENT - CASE HARDEN

SCALE: 1" = 1"
DATE: 9-19-70
APPROVED BY:
DRAWN BY D. G. H.
REVISED

PARALLEL CLAMP-LOOSE JAW

SHEET 3 OF 4
UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2
DRAWING NUMBER 10-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-10-10-18

Drawing No. 10-10A4

PARALLEL CLAMP - STRAIGHT CLIP

EQUIPMENT: Drill press

TOOLS:
- scriber
- file card
- layout dye
- 3" dividers
- prick punch
- 11/64" drill
- center punch
- 6" steel rule
- hand hacksaw
- layout hammer
- abrasive cloth
- 6" mill file
- combination square
- 6" round file

SAFETY PRECAUTIONS:

1. Never attempt to clean a taper hole in a spindle while it is revolving.
2. Always remove the chuck key after fastening a drill in a chuck.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authorization.

PROCEDURE:

1. Select correct gauge of sheet steel and cut to length using hand hacksaw.
2. Layout according to print.
3. Drill 11/64" hole.
4. Cut to layout lines.
5. File radii as required.
6. Remove all burrs.
7. Polish with abrasive cloth.
8. Inspect as per print.

JOB SHEET

Job No. J-10-10-19 Drawing No. 10-10A4

PARALLEL CLAMP - ADJUSTING SCREW

EQUIPMENT: Lathe and power cutoff saw

TOOLS:
- file card
- lathe dog
- center gauge
- cutting oil
- screw-pitch gauge
- 6" steel rule
- knurling tool
- #3 center drill
- 0-1" micrometer
- lathe collet set
- 10" mill file
- 1/16" necking tool
- 60° threading tool
- straight toolholder
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Never attempt to clean metal particles from knurl while rolls are in motion.
2. Always stop the lathe before making any adjustment.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authorization to do so.

PROCEDURE:

1. Select material and cut to rough length on power cutoff saw.
2. Mount work piece in lathe collet or chuck.
3. Face one end and center drill.
4. Face opposite end and center drill allowing sufficient additional material to permit removal of center holes when machining operations between centers are completed.
5. Mount work piece between centers.
6. Turn 1/2" diameter as close to lathe dog as possible.
7. Knurl diameter allowing for removal of center when finishing screw.
8. Reverse work piece between centers (protect knurl with soft metal).
9. Turn thread diameter allowing additional length for center removal when finishing screw.
10. Turn 7/16" diameter and neck 1/16" groove to 21/64" diameter (refer to Operation Sheet No. SL-1-8).
11. Chase threads and fit to threaded jaw.
12. Mount work piece in collet, face off both centers and finish to length.
13. Turn off 1/16" wide band of knurling to 7/16" diameter at each end of knurled head as per print.
14. File radius on each end.
15. Remove all sharp edges.
16. Inspect as per print.

JOB SHEET

Job No. J-10-10-20

Drawing No. 10-10A4

PARALLEL CLAMP - CLAMPING SCREW

EQUIPMENT: Lathe and power cutoff saw.

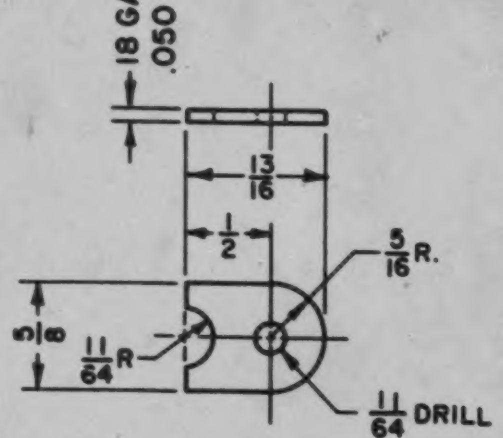
TOOLS:
lathe dog
cutting oil
center gauge
screw-pitch gauge
6" steel rule
knurling tool
#4 center drill
0-1" micrometer
lathe collet set
60° threading tool
10" mill file
straight toolholder
left hand toolholder
right hand facing tool
right hand turning tool
Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

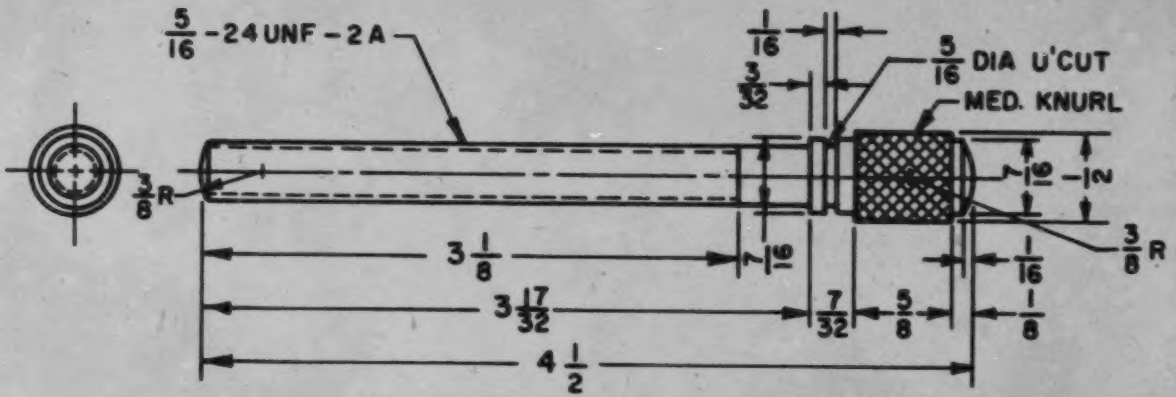
1. Be sure to remove all burrs from threads before handling.
2. Check all dimensions carefully to limit material loss.
3. Do not remove chips from threads with rags or waste.

PROCEDURE:

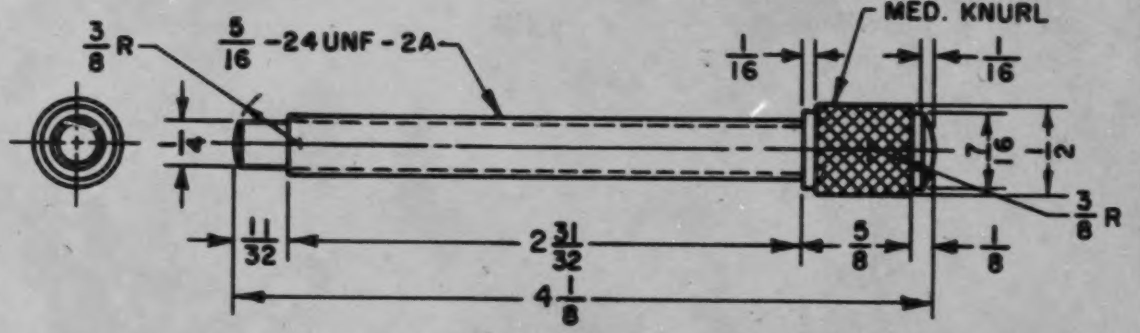
1. Select material and cut to rough length on power cutoff saw.
2. Mount work piece in lathe chuck or collet.
3. Face one end and center drill.
4. Face opposite end and center drill allowing sufficient additional material to permit removal of center holes when machining operations between centers are completed.
5. Mount work piece between centers.
6. Turn 1/2" diameter as close to lathe dog as possible.
7. Knurl diameter allowing for removal of center when finishing screw.
8. Reverse work piece between centers.
9. Turn thread diameter allowing additional length for center removal when finishing screw.
10. Chase threads and fit to threaded jaw.
11. Turn small pilot end diameter as per print allowing for center removal.
12. Turn 30° chamfer on end of thread.
13. Mount work piece in collet and remove center from knurled end.
14. File radius on each end.
15. Remove all sharp edges.
16. Inspect as per print.


18 GA.
.050
13/16
1/2
5/16 R.
5/8
11/64 R
11/64 DRILL

STRAIGHT CLIP


5/16 -24 UNF - 2 A
1/16
5/16 DIA U'CUT
3/32
MED. KNURL
7/16
1/2
3/8 R
3/8 R
3 1/8
7/16
1/16
3 17/32
7/32
5/8
1/8
4 1/2

ADJUSTING SCREW


3/8 R
5/16 -24 UNF - 2A
MED. KNURL
1/16
1/16
1/4
7/16
1/2
3/8 R
11/32
2 31/32
5/8
1/8
4 1/8

CLAMPING SCREW

MATERIAL – AISI 1018 C.R.S.

SCALE: 1" = 1"
DATE: 9-19-70
APPROVED BY:
DRAWN BY D. G. H.
REVISED

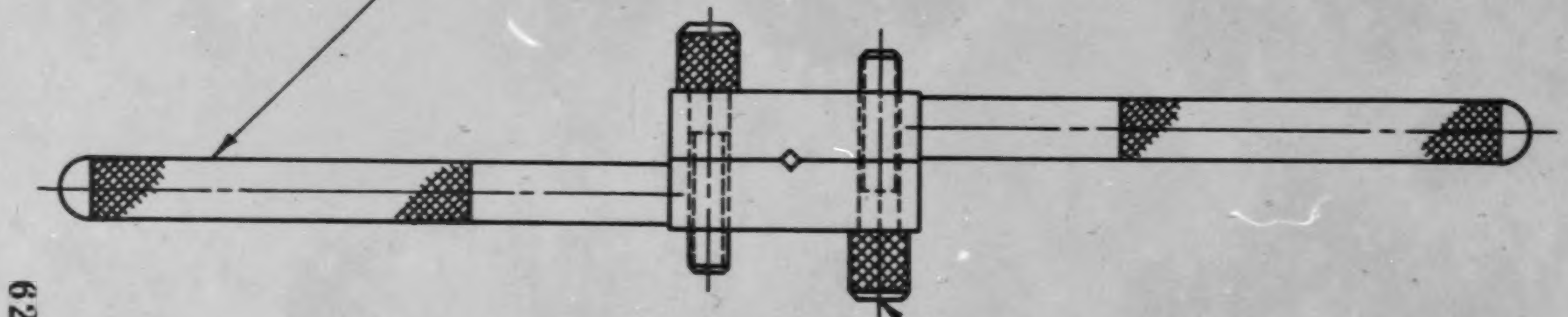
PARALLEL CLAMP-DETAILS

SHEET 4 OF 4

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
10-10A4

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



WRENCH HANDLE
2 REQUIRED
DWG. NO. II-10A2

THUMB SCREW
2 REQUIRED
DWG. NO. II-10A2

SCALE: 1" = 1"
DATE: 8-14-70
APPROVED BY:
DRAWN BY D. G. H.
REVISED

TAP WRENCH-ASSEMBLY

SHEET 1 OF 2

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2

DRAWING NUMBER
II-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-11-10-21 Drawing No. 11-10A2

TAP WRENCH - HANDLES

EQUIPMENT: Power cutoff saw, drill press, bench vise, lathe, and heat treating furnace.

TOOLS:
tongs
scriber
file card
1/4" drill
layout dye
cutting oil
prick punch
center punch
6" steel rule
knurling tool
abrasive cloth
soft vise jaws
asbestos gloves
#3 center drill
#7 drill (.201)
outside calipers
lathe collet set
10" mill file
3/16" radius gauge
adjustable tap wrench
straight toolholder
1/4"-20 N.C. tap set
6" square needle file
6" combination square
left hand toolholder
right hand facing tool
right hand turning tool
Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Observe all shop safety regulations.
2. Check all dimensions carefully to limit material loss.
3. Operate no equipment without authority to do so.

PROCEDURE:

1. Select and cut 2 pieces of square C.R. steel on power cutoff saw, allowing 1/4" additional material at one end for center drilling.

   NOTE: The same procedure is to be followed for both handles.

2. Mount work piece in 4 jaw chuck.
3. Face and center drill. Do not exceed 1/4" depth.
4. Support work piece with dead center.
5. Turn 3/8" diameter.
6. Knurl to specified length allowing for removal of center hole.
7. Repeat steps 2 through 6 for second handle.
8. Mount in collet and remove center hole. (Both handles)
9. Form radius on handle end as per print. (Both handles)
10. Reverse work piece in collet and face to length.

    NOTE: Work pieces should be set up and drilled together to insure alignment of holes. See assembly drawing.

11. Layout for tapped holes, clearance holes, and 90° notch.
12. Drill #7 holes to be tapped.
13. Drill clearance holes.
14. Tap 1/4"-20 N.C. hole in each work piece.
15. File 90° notch in each work piece to form a square when matched together.
16. Break all sharp corners.
17. Polish with abrasive cloth.
18. Case harden.
19. Repolish with abrasive cloth.
20. Inspect as per print.

JOB SHEET

Job No. J-11-10-22

Drawing No. 11-10A1

TAP WRENCH - THUMB SCREWS

EQUIPMENT: Lathe

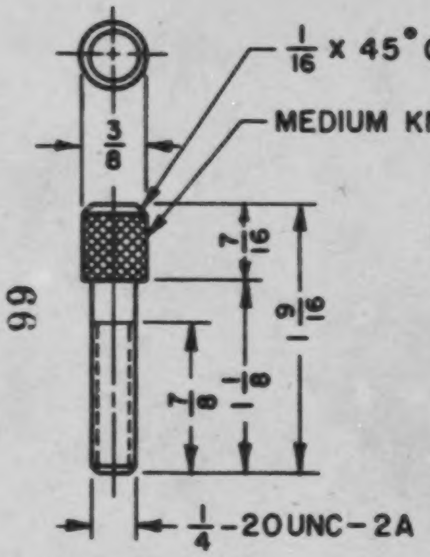
TOOLS:
- file card
- cutting oil
- hand hacksaw
- center gauge
- screw-pitch gauge
- 6" steel rule
- knurling tool
- 0-1" micrometer
- lathe collet set
- 60° threading tool
- 10" mill file
- left hand toolholder
- right hand facing tool
- right hand turning tool
- parting blade and holder

SAFETY PRECAUTIONS:

1. Support end of small diameter work when using knurling tool.
2. Check all dimensions carefully to limit material loss.
3. Operate no equipment without authority to do so.

PROCEDURE:

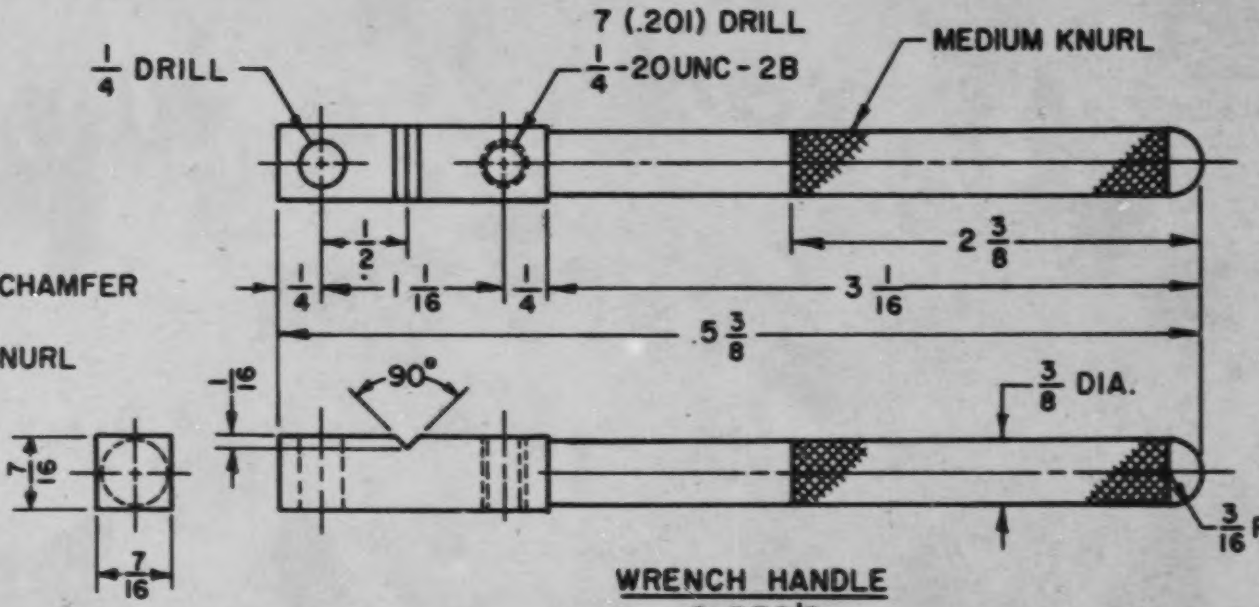
1. Select and cut two pieces of stock to sufficient length with hand hacksaw to allow use of knurling tool next chuck.
2. Mount work piece in chuck, face end, and turn thread diameter.
3. Turn 30° angle on end of thread diameter.
4. Chase thread as per print.
5. Knurl to proper length.
6. Part off screw allowing material for facing.
7. Mount work piece in collet, face head to length, and chamfer.
8. Remove all burrs.
9. Repeat above operations for second screw.
10. Inspect as per print.



$\frac{1}{16}$ X 45° CHAMFER
MEDIUM KNURL
$\frac{3}{8}$
$\frac{7}{16}$
$1\frac{9}{16}$
$1\frac{1}{8}$
$\frac{7}{8}$
$\frac{1}{4}$-20UNC-2A

THUMB SCREW

2 REQ'D.



$\frac{1}{4}$ DRILL
7 (.201) DRILL
$\frac{1}{4}$-20UNC-2B
MEDIUM KNURL
$\frac{1}{2}$
$\frac{1}{4}$
$1\frac{1}{16}$
$\frac{1}{4}$
$2\frac{3}{8}$
$3\frac{1}{16}$
$5\frac{3}{8}$
$\frac{1}{16}$
90°
$\frac{3}{8}$ DIA.
$\frac{7}{16}$
$\frac{7}{16}$
$\frac{3}{16}$ R

WRENCH HANDLE

2 REQ'D.

MATERIAL — AISI 1018 C.R.S.

SCALE: 1" = 1" DATE: 8-14-70	APPROVED BY:	DRAWN BY REVISED

TAP WRENCH — HANDLES AND SCREWS

SHEET 2 OF 2	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2	DRAWING NUMBER 11-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-12-10-23 Drawing No. 12-10A1

PUNCH SET

EQUIPMENT: Lathe and heat treating furnace.

TOOLS:
tongs
file card
cutting oil
6" steel rule
knurling tool
abrasive cloth
hand hacksaw
#4 center drill
asbestos gloves
outside calipers
lathe collet set
10" mill file
straight toolholder
left hand toolholder
right hand facing tool
right hand turning tool
Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

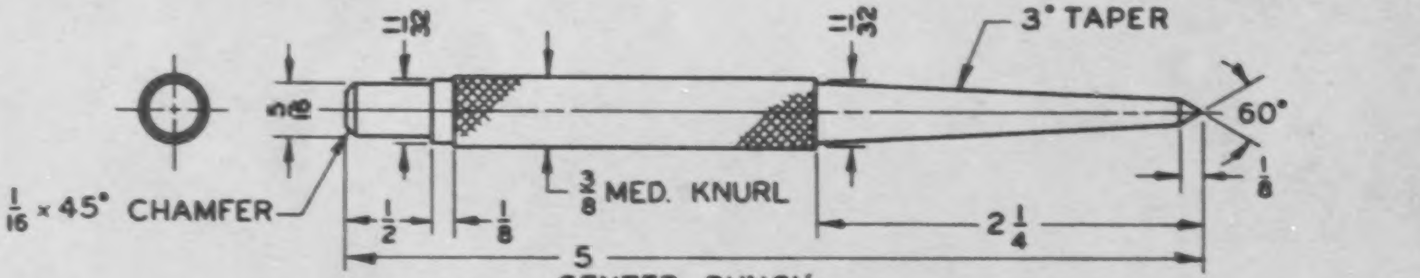
1. Check all dimensions carefully to limit material loss.
2. Always stop machine before brushing chips from knurled work piece.
3. Operate no equipment without authority to do so.

PROCEDURE:

1. Select drill rod and cut to required length allowing excess material for center drilling. Cut sufficient material to make three punches.
2. Mount work piece in chuck and center drill one end of each piece.
3. Support center drilled end with dead center and knurl the required length at the tailstock end. Allow for removal of center hole. Knurl all three pieces.
4. Turn the head diameters on each work piece as per print.
5. Set compound rest to required angle for machining 3° taper.
6. Reverse work piece, mount in collet, and turn required taper on center and drift punches.
7. Set compound rest to the required angle for 60° point on center punch.
8. Remove excess material containing the center drill hole in center punch.
9. Turn the required 60° point on center punch as per print.
10. File and polish machined surfaces on center punch with abrasive cloth.
11. Remove material containing the center drill hole in drift punch.
12. File and polish machined surfaces on drift punch with abrasive cloth.

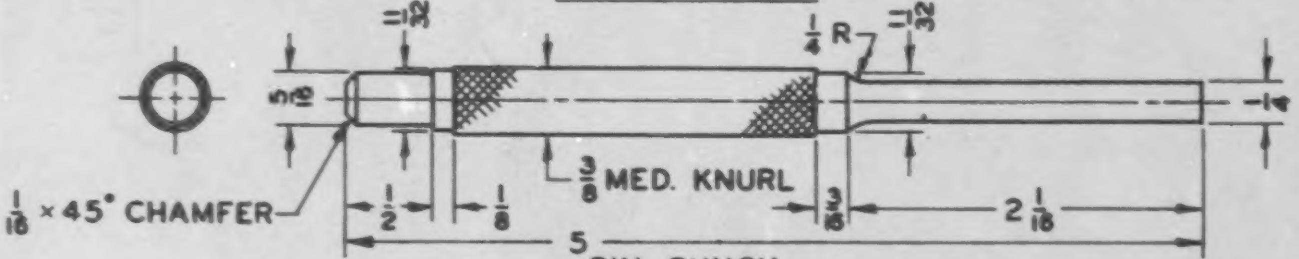
13. Turn punch diameter and radius shoulder on pin punch as per print.
14. File and polish machined surfaces on pin punch with abrasive cloth.
15. Harden and temper all punches.
16. Repolish machined surfaces on all punches with abrasive cloth.
17. Inspect as per print.

NOTE: The drift punch is machined without the 60° point. The pin punch requires no taper turning.



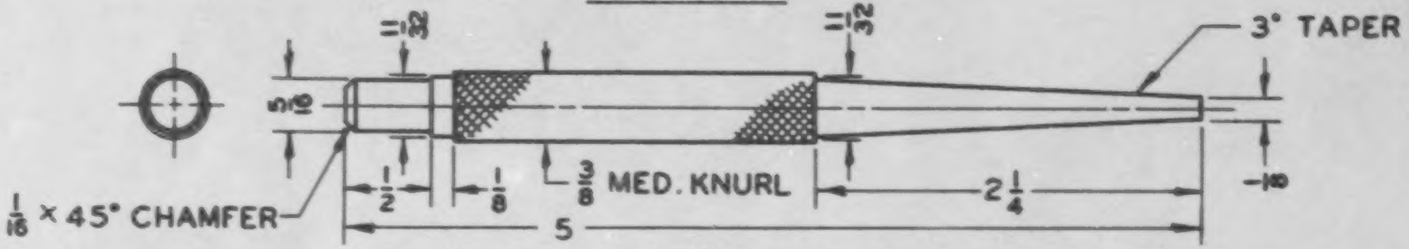
11/32
11/32
3° TAPER
60°
5/16
1/8
1/16 × 45° CHAMFER
3/8 MED. KNURL
1/2
1/8
2 1/4
5

CENTER PUNCH



11/32
1/4 R
11/32
5/16
1/4
3/8 MED. KNURL
1/16 × 45° CHAMFER
1/2
1/8
3/16
2 1/16
5

PIN PUNCH



11/32
11/32
3° TAPER
5/16
3/8 MED. KNURL
1/8
1/16 × 45° CHAMFER
1/2
1/8
2 1/4
5

DRIFT PUNCH

MATERIAL - DRILL ROD AISI TYPE O2
(OIL HARDENING)

HEAT TREATMENT - HARDEN AND TEMPER

SCALE: 1 = 1 DATE: 12-30-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
PUNCH SET		
SHEET 1 OF 1	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2	DRAWING NUMBER 12-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-13-10-24 Drawing No. 13-10A1

COLD CHISEL

EQUIPMENT: Shaper, lathe, heat treating furnace, power cutoff saw, and bench grinder.

TOOLS:
tongs
scriber
file card
layout dye
6" steel rule
asbestos gloves
10" mill file
straight toolholder
right hand facing tool

SAFETY PRECAUTIONS:

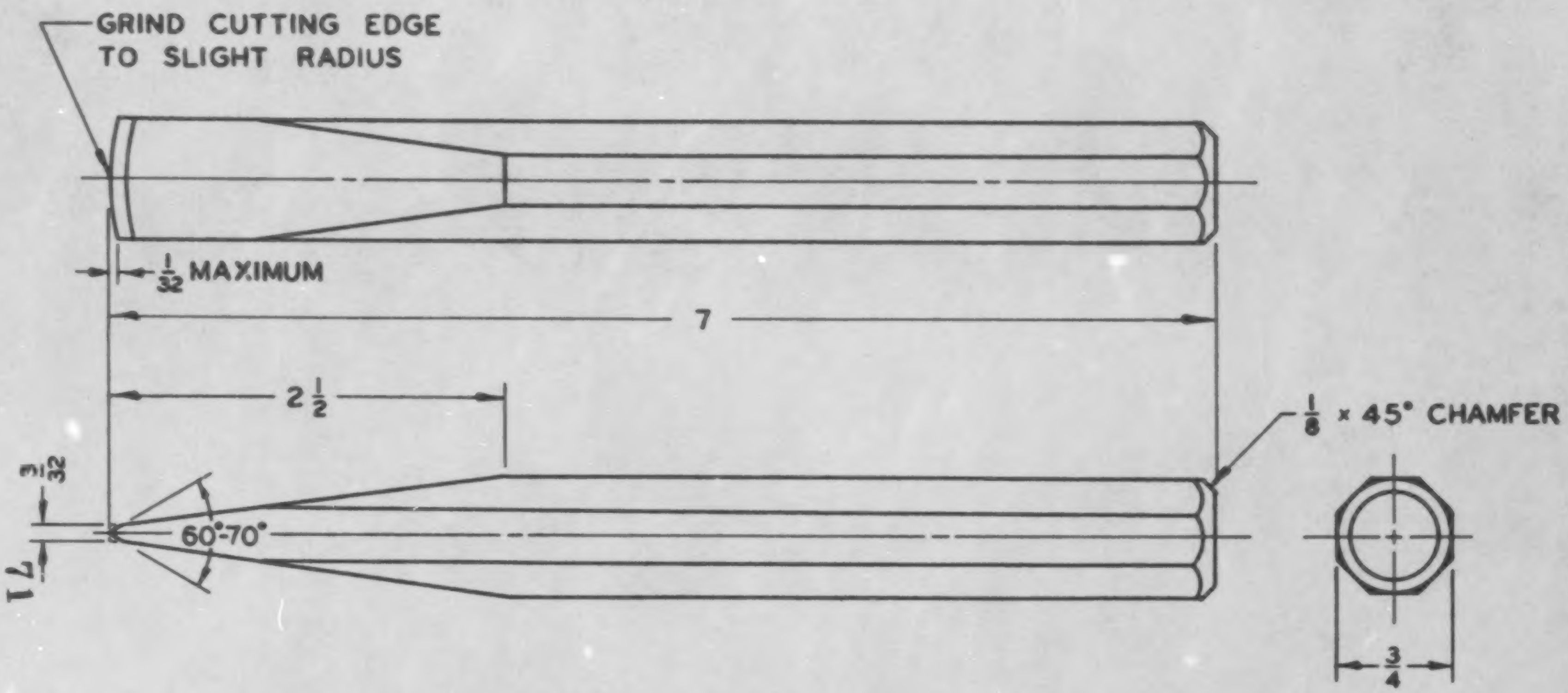
1. Stop movement of machine before making adjustments.
2. Always check speed control levers before starting machine.
3. Check all dimensions carefully to limit material loss.
4. Operate no equipment without authority to do so.

PROCEDURE:

1. Select correct octagonal tool steel.
2. Cut stock to length on power cutoff saw.
3. Mount work piece in lathe and face one end.
4. Turn 45° chamfer as per print.
5. Layout for taper.
6. Mount work piece to layout in shaper (refer to Operation Sheet Nos. SL-5-1, 2, 3, 4, and 5).
7. Shape taper to layout allowing 1/64" for finishing.
8. Repeat steps 6 and 7 for opposite side of the chisel.
9. Draw file to layout lines.
10. Draw file all sides of octagon.
11. Heat treat.
12. Hand grind 60° to 70° cutting edge.

    NOTE: The cutting edge should be slightly curved instead of straight across.

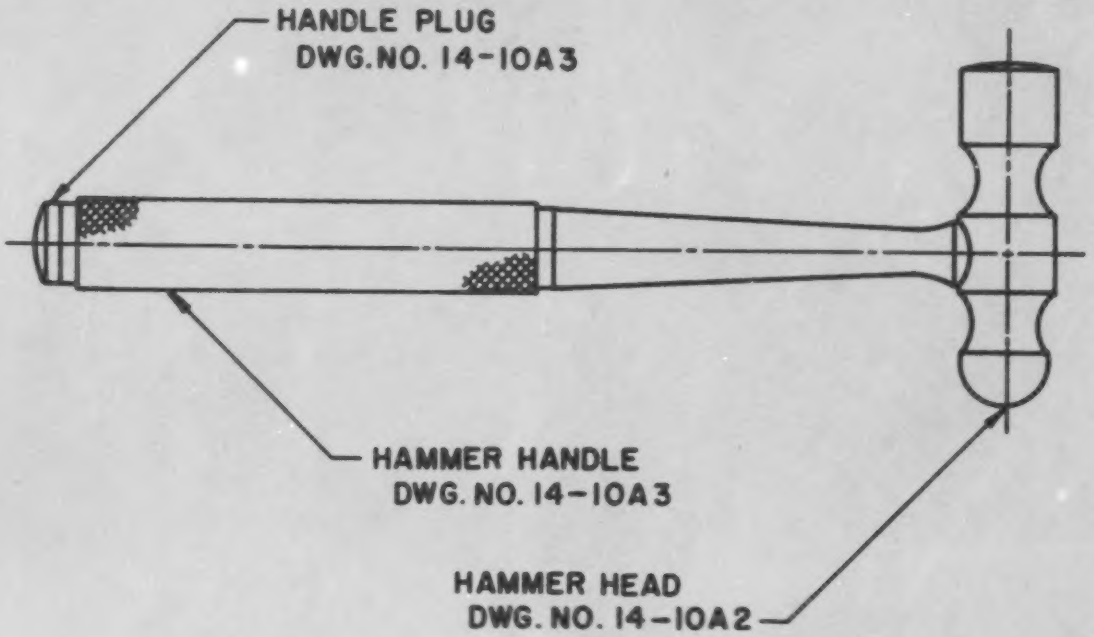
13. Inspect as per print.


GRIND CUTTING EDGE
TO SLIGHT RADIUS
1/32 MAXIMUM
7
2 1/2
1/8 × 45° CHAMFER
3/32
60°-70°
3/4

MATERIAL - TOOL STEEL AISI TYPE W1
(WATER HARDENING)
HEAT TREATMENT - HARDEN AND TEMPER

SCALE: 1 = 1	APPROVED BY:	DRAWN BY D.G.H.
DATE: 12-30-70		REVISED
COLD CHISEL		
SHEET 1 OF 1	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2	DRAWING NUMBER 13-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY


HANDLE PLUG
DWG.NO. 14-10A3
HAMMER HANDLE
DWG. NO. 14-10A3
HAMMER HEAD
DWG. NO. 14-10A2

SCALE: 1/2" = 1" DATE: 8-12-70	APPROVED BY:	DRAWN BY D. G. H. REVISED
BALL PEEN HAMMER – ASSEMBLY		
SHEET 1 OF 3	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ±1/64 DECIMAL DIMENSIONS ±.005 ANGULAR DIMENSIONS ±1 2	DRAWING NUMBER 14-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-14-10-25 Drawing No. 14-10A2

BALL PEEN HAMMER - HEAD

EQUIPMENT: Lathe, power cutoff saw, heat treating furnace, and vertical milling machine.

TOOLS:
- tongs
- scriber
- lathe dog
- file card
- prick punch
- cutting oil
- 37/64" drill
- center punch
- 6" steel rule
- abrasive cloth
- asbestos gloves
- #4 center drill
- lathe collet set
- 3/4" counterbore
- 1/2" radius tool
- 3" outside caliper
- 10" mill file
- straight toolholder
- 1/2" radius gauge
- 5/8" - 18 N.F. tap set
- adjustable tap wrench
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

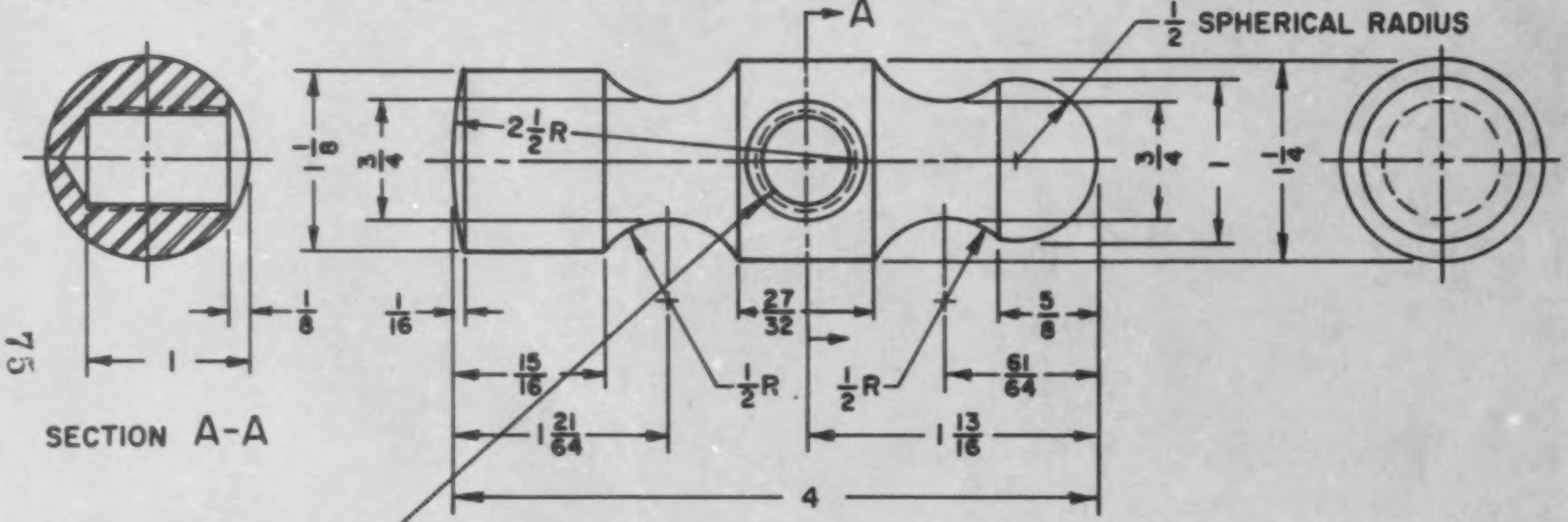
SAFETY PRECAUTIONS:

1. Asbestos gloves should be worn while operating a heat treating furnace.
2. Check all dimensions carefully to limit material loss.
3. Operate no equipment without authority to do so.

PROCEDURE:

1. Select material and cut to length on power cutoff saw allowing for center holes.
2. Mount work piece in chuck, face and center drill both ends.
3. Mount work piece between centers.
4. Turn 1-1/4" diameter back to lathe dog.
5. Turn head diameter to length allowing for removal of center hole.
6. Turn 1/2" radius next to head diameter as per print.
7. Reverse work piece between centers.
8. Mark off length of the 1-1/4" diameter and the 1/2" radius as per print.
9. Turn ball diameter beyond length specified.
10. Turn 1/2" radius next to ball diameter as per print.
11. Mount work piece in collet.
12. Form ball peen as per print.
13. Reverse work piece and form head.

14. Polish with abrasive cloth.
15. Layout head for tapped hole and center punch.
16. Mount work piece on vertical milling machine and pick up center.
17. Drill, tap and counterbore as per print.
18. Case harden.
19. Repolish with abrasive cloth.
20. Inspect as per print.


A
$\frac{1}{2}$ SPHERICAL RADIUS
$2\frac{1}{2}$R
$1\frac{1}{8}$
$\frac{3}{4}$
1
$1\frac{1}{4}$
$\frac{1}{8}$
$\frac{1}{16}$
$\frac{27}{32}$
$\frac{5}{8}$
1
$\frac{15}{16}$
$\frac{1}{2}$R
$\frac{1}{2}$R
$\frac{61}{64}$
SECTION A-A
$1\frac{21}{64}$
$1\frac{13}{16}$
4

$\frac{37}{64}$ DRILL, .750
COUNTERBORE–
$\frac{1}{8}$ DP. AS SHOWN
IN SECTION,
$\frac{5}{8}$–18 UNF–2B

MATERIAL–AISI–1018 C.R.S.
HEAT TREATMENT – CASE HARDEN

SCALE: 1" = 1" DATE: 8-12-70	APPROVED BY:	DRAWN BY D. G. H. REVISED
BALL PEEN HAMMER-HEAD		
SHEET 2 OF 3	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1 2	DRAWING NUMBER 14-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-14-10-26

Drawing No. 14-10A3

BALL PEEN HAMMER - HANDLE

EQUIPMENT: Lathe and power cutoff saw.

TOOLS:
- file card
- 3/4" reamer
- screw-pitch gauge
- center gauge
- 6" steel rule
- knurling tool
- #4 center drill
- abrasive cloth
- 1/8" necking tool
- 0-1" micrometer
- 60° threading tool
- 10" mill file
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock taper
- lathe collet set

SAFETY PRECAUTIONS:

1. Keep fingers away from knurling rolls.
2. Check feed rate and direction of movement before putting tool to work piece.
3. Follow safety grooming precautions.

PROCEDURE:

1. Select 1" round aluminum and cut to rough length on power cutoff saw.
2. Mount work piece in chuck.
3. Face and center drill both ends.
4. Mount work piece between centers.
5. Knurl as per print.
6. Reverse handle and place soft metal under lock screw of the dog in order to protect knurled surface.
7. Turn .740 diameter.
8. Turn thread diameter.
9. Form undercut for thread relief.
10. Chamfer 30° to thread depth.
11. Chase 5/8" - 18 N.F. threads to fit head.
12. Form radius next to threaded end to 1/2" diameter as shown on print.
13. Turn taper using offset tailstock method.
14. Reverse work piece and mount in collet.
15. Drill and ream as per print.
16. Polish machined surfaces with abrasive cloth.
17. Inspect as per print.

JOB SHEET

Job No. J-14-10-27

Drawing No. 14-10A3

BALL PEEN HAMMER - HANDLE PLUG

EQUIPMENT: Lathe and power cutoff saw.

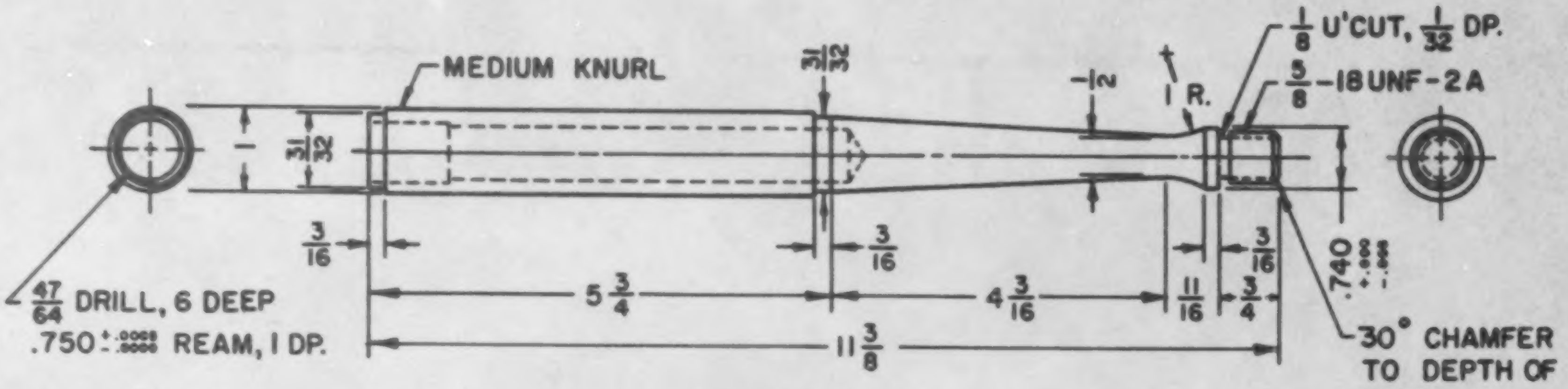
TOOLS:
file card
6" steel rule
abrasive cloth
0-1" micrometer
lathe collet set
10" mill file
1/16" necking tool
left hand toolholder
right hand facing tool
right hand turning tool

SAFETY PRECAUTIONS:

1. Be careful to break all sharp edges prior to polishing with abrasive cloth.
2. Check all dimensions carefully to limit material loss.
3. Operate no equipment without authority to do so.

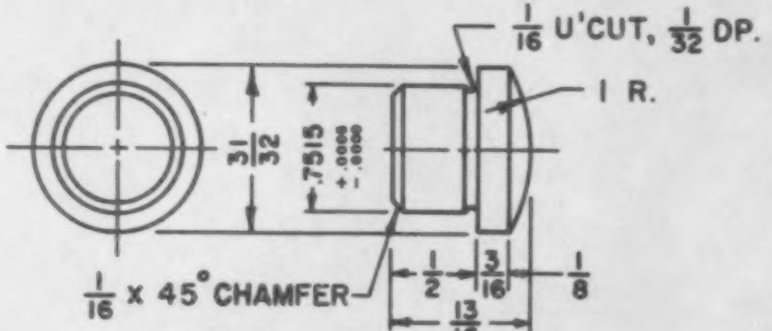
PROCEDURE:

1. Select 1" round aluminum stock and cut to rough length on power cutoff saw.
2. Mount work piece in collet.
3. Face work piece.
4. Turn 3/4" diameter. (Note tolerance.)
5. Turn 1/16" x 45° chamfer.
6. Form 1/16" x 1/32" undercut.
7. Reverse work piece in collet.
8. Turn head diameter and radius as per print.
9. Polish with abrasive cloth.
10. Press plug into handle.
11. Inspect as per print.


MEDIUM KNURL
31/32
1
31/32
1/2
1 R.
1/8 U'CUT, 1/32 DP.
5/8-18UNF-2A
3/16
3/16
3/16
5 3/4
4 3/16
11/16
3/4
11 3/8
.740 +.000 -.002
47/64 DRILL, 6 DEEP
.750 +.0008 -.0000 REAM, 1 DP.
30° CHAMFER
TO DEPTH OF
THREAD

HANDLE

SCALE - 1/2 = 1


1/16 U'CUT, 1/32 DP.
1 R.
31/32
.7515 +.0000 -.0005
1/16 x 45° CHAMFER
1/2
3/16
1/8
13/16

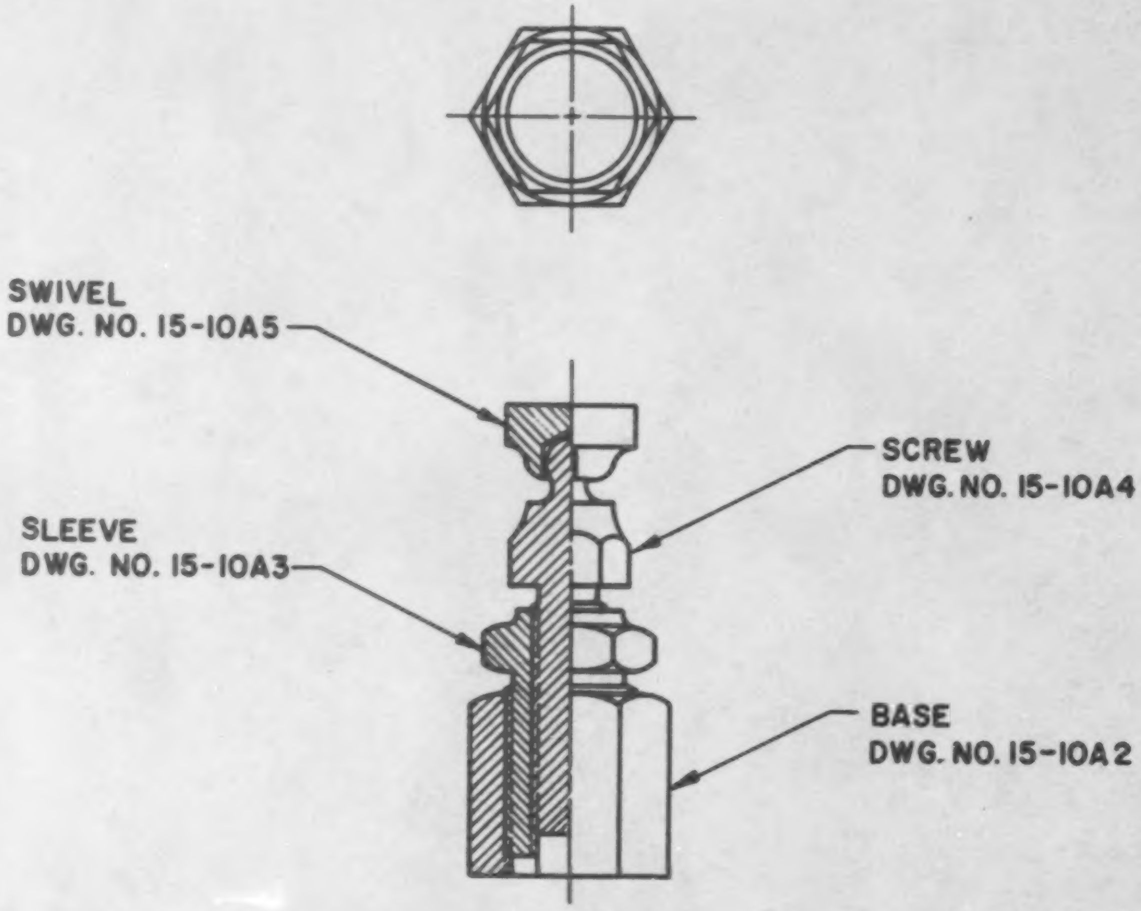
HANDLE PLUG

SCALE - 1=1

MATERIAL — ALUMINUM

SCALE: AS SHOWN DATE: 8-12-70	APPROVED BY:	DRAWN BY D. G. H. REVISED
BALL PEEN HAMMER-HANDLE & HANDLE PLUG		
SHEET 3 OF 3	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2	DRAWING NUMBER 14-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY


SWIVEL
DWG. NO. 15-10A5
SLEEVE
DWG. NO. 15-10A3
SCREW
DWG. NO. 15-10A4
BASE
DWG. NO. 15-10A2

SCALE: 1" = 1"
DATE: 11-7-70
APPROVED BY:
DRAWN BY D. G. H.
REVISED

JACK SCREW - ASSEMBLY

SHEET 1 OF 5

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
15-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-15-10-28   Drawing No. 15-10A2

JACK SCREW - BASE

EQUIPMENT: Lathe and power cutoff saw.

TOOLS:
- file card
- 11/16" drill
- 6" steel rule
- #3 center drill
- 10" mill file
- 3/4"-16 N.F. tap set
- left hand toolholder
- right hand facing tool
- cutting oil
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle
- adjustable tap wrench

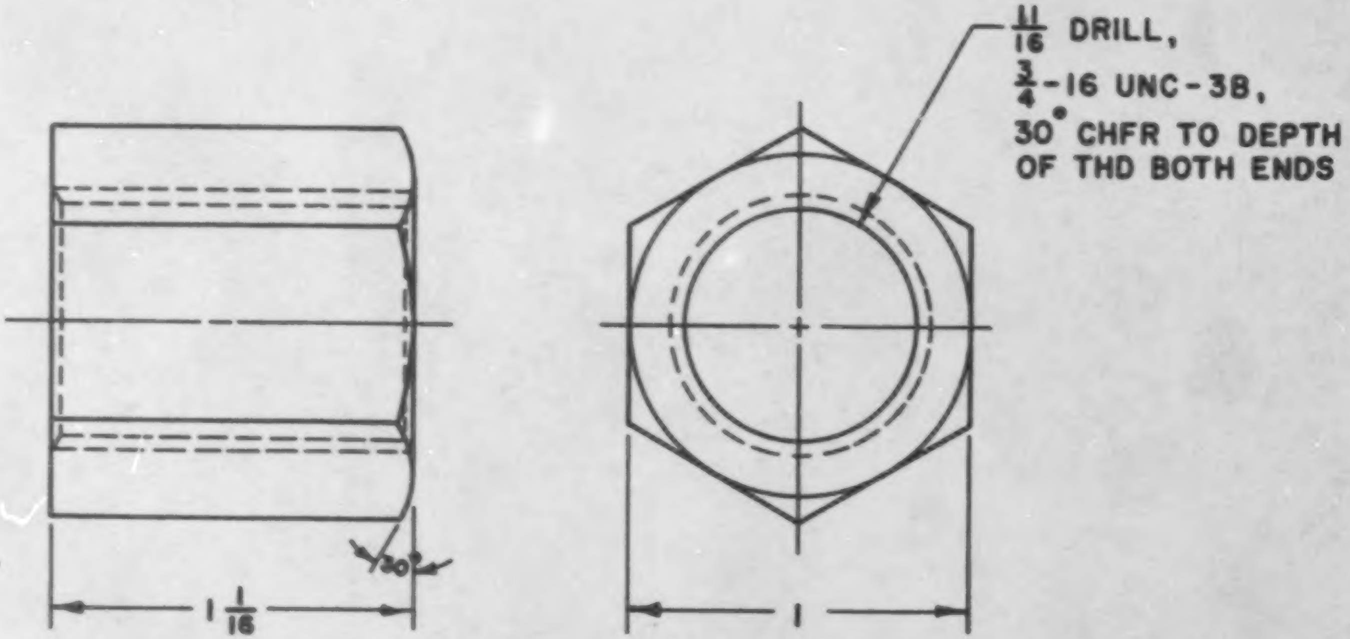
SAFETY PRECAUTIONS:

1. Never use power when tapping on the lathe.
2. Allow sufficient clearance between chuck and compound rest.

PROCEDURE:

1. Select hex. C.R. steel and cut two pieces to rough length on power cutoff saw.
2. Mount work piece in chuck.
3. Face and center drill.
4. Drill 11/16" hole.
5. Chamfer 30° to thread depth to assist starting tap.
6. Tap 3/4"-16 N.F. using tailstock center to support tap.
7. Form 30° chamfer on one end.
8. Reverse work piece in chuck.
9. Face to length.
10. Chamfer internal thread 30° to thread depth.
11. Remove all burrs.
12. Inspect as per print.

NOTE: Same procedure will be used for second base.



$\frac{11}{16}$ DRILL,
$\frac{3}{4}$-16 UNC-3B,
30° CHFR TO DEPTH
OF THD BOTH ENDS

MATERIAL - AISI-1018 C.R.S. HEX STOCK

SCALE: 2" = 1"	APPROVED BY:	DRAWN BY D. G. H.
DATE: 9-26-70		REVISED
JACK SCREW - BASE		
SHEET 2 OF 5	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ±1/64 DECIMAL DIMENSIONS ±.005 ANGULAR DIMENSIONS ±1 2	DRAWING NUMBER 15-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-15-10-29 Drawing No. 15-10A3

JACK SCREW - SLEEVE

EQUIPMENT: Lathe and power cutoff saw.

TOOLS:
- file card
- center gauge
- screw-pitch gauge
- 6" steel rule
- #4 center drill
- "U" drill (.368)
- 10" mill file
- 60° threading tool
- 3/32" necking tool
- adjustable tap wrench
- 7/16"-14 N.C. tap set
- left hand toolholder
- cutting oil
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

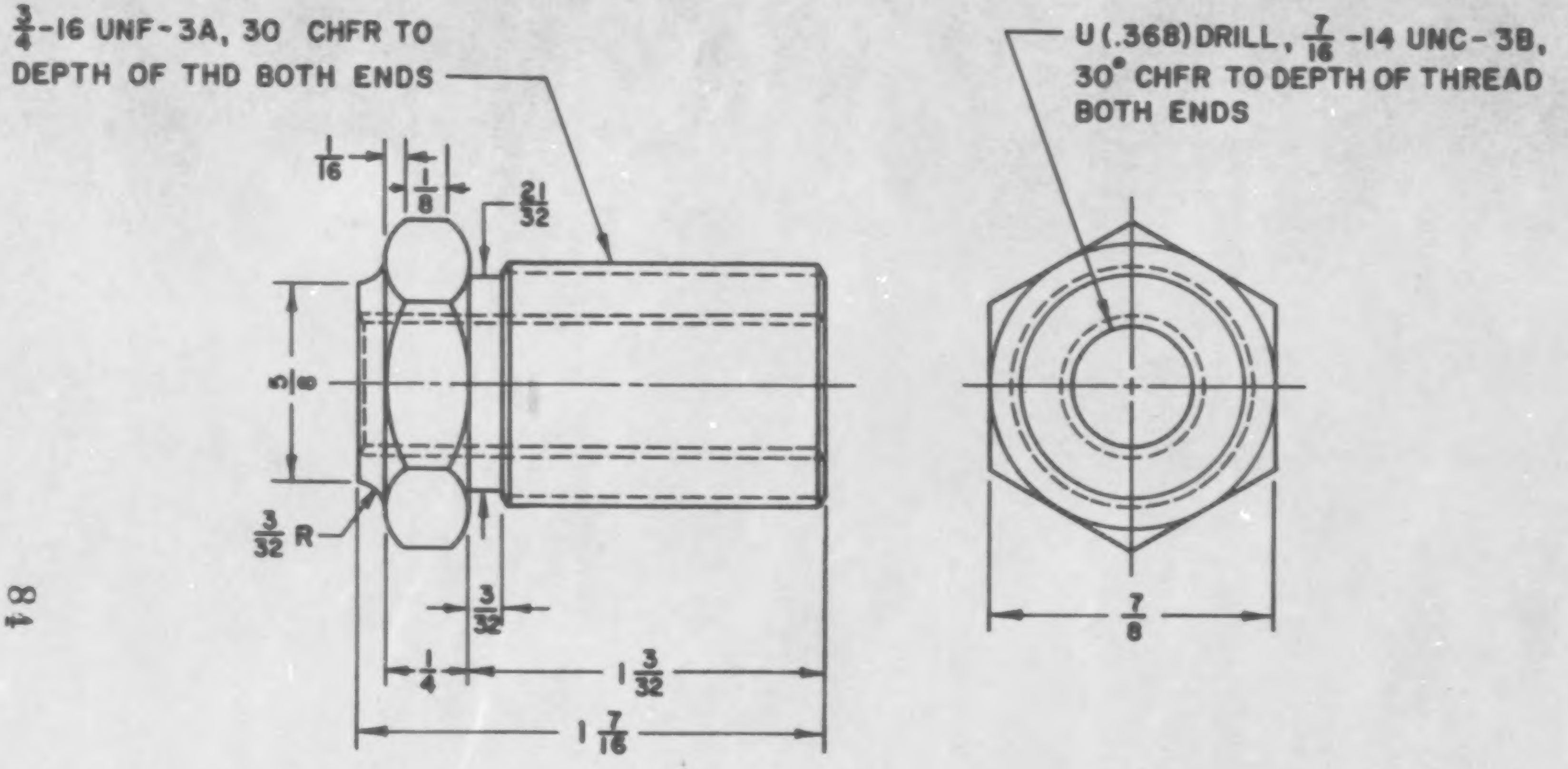
1. Be careful not to run the cutting tool into the chuck.
2. Files must not be used on the lathe unless they are fitted with handles.

PROCEDURE:

1. Select hex. C.R. steel and cut sufficient material on power cutoff saw for two sleeves.
2. Mount work piece in chuck.
3. Face end and center drill.
4. Extend work piece 2" from face of chuck and support with tailstock center.
5. Turn 3/4" thread diameter as specified.
6. Chamfer starting end of thread 30° to thread depth.
7. Form 3/32" undercut for thread relief.
8. Chase 3/4"-16 N.F. threads to fit base.
9. Remove tailstock center.
10. Drill center hole with "U" drill.
11. Tap 7/16"-14 N.C. using tailstock center to support tap.
12. Chamfer internal thread 30° to thread depth.
13. Form radius on hex. portion next to undercut.
14. Part to rough length.
15. Reverse work piece in chuck.
16. Face to length.
17. Form 3/32" radius.

18. Form radius on hex. portion.
19. Draw file flats on hexagon.
20. Remove all burrs.
21. Inspect as per print.

NOTE: Same procedure will be used for second sleeve.


$\frac{3}{4}$-16 UNF-3A, 30 CHFR TO
DEPTH OF THD BOTH ENDS
U (.368) DRILL, $\frac{7}{16}$-14 UNC-3B,
30° CHFR TO DEPTH OF THREAD
BOTH ENDS
$\frac{1}{16}$
$\frac{1}{8}$
$\frac{21}{32}$
$\frac{5}{8}$
$\frac{3}{32}$ R
$\frac{3}{32}$
$\frac{1}{4}$
$1\frac{3}{32}$
$1\frac{7}{16}$
$\frac{7}{8}$

MATERIAL - AISI-1018 C.R.S. HEX STOCK

SCALE: 2" = 1"	APPROVED BY:	DRAWN BY D.G.H.
DATE: 11-7-70		REVISED
JACK SCREW - SLEEVE		
SHEET 3 OF 5	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ±1/64 DECIMAL DIMENSIONS ±.005 ANGULAR DIMENSIONS ±1 2	DRAWING NUMBER 15-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-15-10-30

Drawing No. 15-10A4

JACK SCREW - SCREW

EQUIPMENT: Lathe and power cutoff saw.

TOOLS:
- file card
- cutting oil
- center gauge
- screw-pitch gauge
- 6" steel rule
- #4 center drill
- 0-1" micrometer
- 1/8" radius tool
- 1/8" radius gauge
- 60° threading tool
- 10" mill file
- 3/32" necking tool
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle
- parting blade and holder
- left hand toolholder

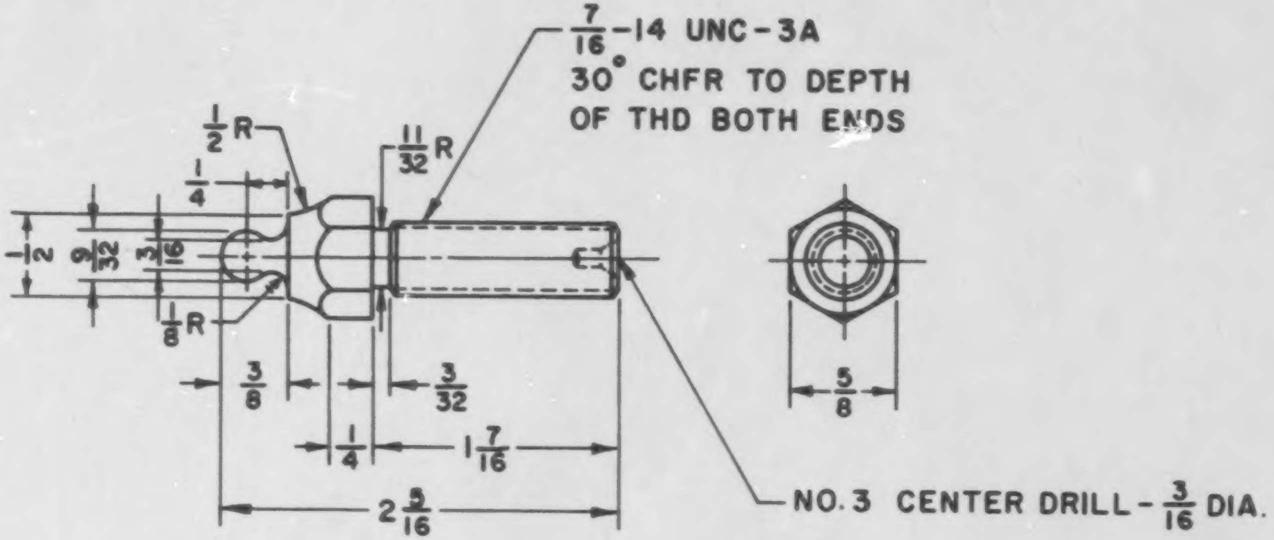
SAFETY PRECAUTIONS:

1. Never shift tools in lathe tool post while machine is in operation.
2. Cover tool with a cloth to protect hands while making measurements on work piece.

PROCEDURE:

1. Select hex. C.R. steel and cut sufficient material on power cutoff saw to make two screws.
2. Mount work piece in chuck.
3. Face end and center drill.
4. Extend work piece 2-5/8" from face and support end with tailstock center.
5. Turn 7/16" thread diameter 1-7/16" long.
6. Chamfer starting end of thread 30° to thread depth.
7. Form neck for thread relief.
8. Chase 7/16"-14 N.C. threads to fit sleeve.
9. Part to length.
10. Mount work piece in collet.
11. Form 9/32" ball end.
12. Form 1/8" radius.
13. Form 1/2" radius.
14. Draw file hexagonal flats.
15. Remove all burrs.
16. Inspect as per print.

NOTE: Same procedure will be used for second screw.


$\frac{7}{16}$-14 UNC-3A
30° CHFR TO DEPTH
OF THD BOTH ENDS
$\frac{1}{2}$R
$\frac{1}{4}$
$\frac{11}{32}$R
$\frac{1}{2}$
$\frac{9}{32}$
$\frac{3}{16}$
$\frac{1}{8}$R
$\frac{3}{8}$
$\frac{3}{32}$
$\frac{1}{4}$
$1\frac{7}{16}$
$2\frac{5}{16}$
$\frac{5}{8}$
NO. 3 CENTER DRILL - $\frac{3}{16}$ DIA.

MATERIAL - AISI-1018 C.R.S. HEX STOCK

SCALE: 1" = 1"
DATE: 11-7-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

JACK SCREW - SCREW

SHEET 4 OF 5

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2

DRAWING NUMBER
15-10A4

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-15-10-31

Drawing No. 15-10A5

JACK SCREW - SWIVEL

EQUIPMENT: Lathe and power cutoff saw.

TOOLS:
file card
cutting oil
9/32" drill
hand hacksaw
6" steel rule
abrasive cloth
#3 center drill
0-1" micrometer
ball peen hammer
1/8" radius tool
1/8" radius gauge
10" mill file
left hand toolholder
right hand facing tool
right hand turning tool
Jacobs drill chuck with Morse taper to fit lathe tailstock taper

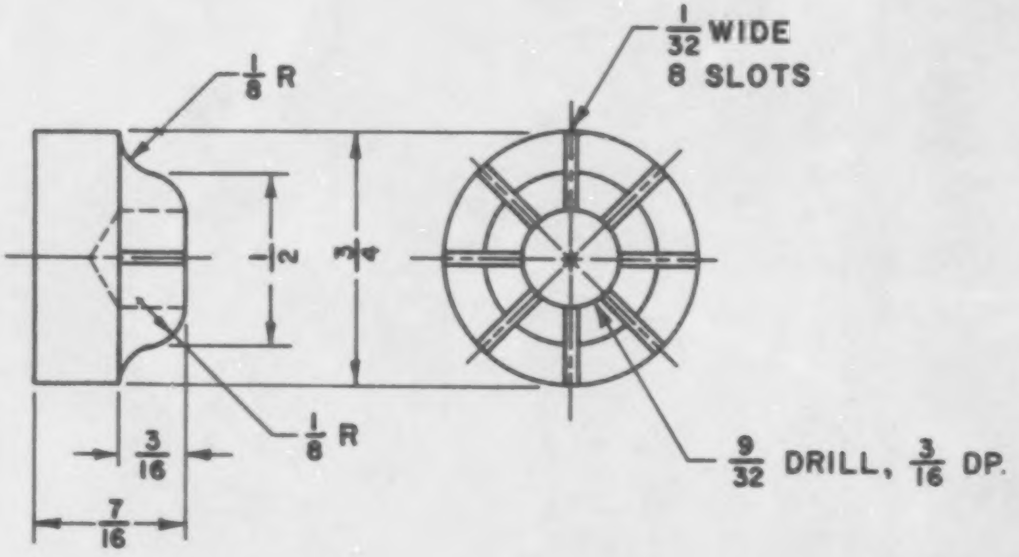
SAFETY PRECAUTIONS:

1. Observe all shop safety rules.
2. Always be aware of the location of the STOP button.

PROCEDURE:

1. Select C.R. steel and cut two pieces to rough length on power cutoff saw.
2. Mount work piece in chuck.
3. Face end and center drill.
4. Drill 9/32" hole to receive ball end of screw.
5. Form 1/8" radii.
6. Reverse work piece in chuck.
7. Face to length.
8. Saw 8 slots in radius end of swivel as per print using hand hacksaw.
9. Remove all burrs.
10. Insert ball end of screw into swivel and peen in place loosely so that swivel will rotate on ball end.
11. Inspect as per print.

NOTE: Use the same procedure for second work piece.



$\frac{1}{8}$ R
$\frac{1}{32}$ WIDE
8 SLOTS
$\frac{1}{2}$
$\frac{3}{4}$
$\frac{1}{8}$ R
$\frac{3}{16}$
$\frac{7}{16}$
$\frac{9}{32}$ DRILL, $\frac{3}{16}$ DP.

MATERIAL - AISI-1018 C.R.S.

SCALE: 2" = 1"

DATE: 9-26-70

APPROVED BY:

DRAWN BY D. G. H.

REVISED

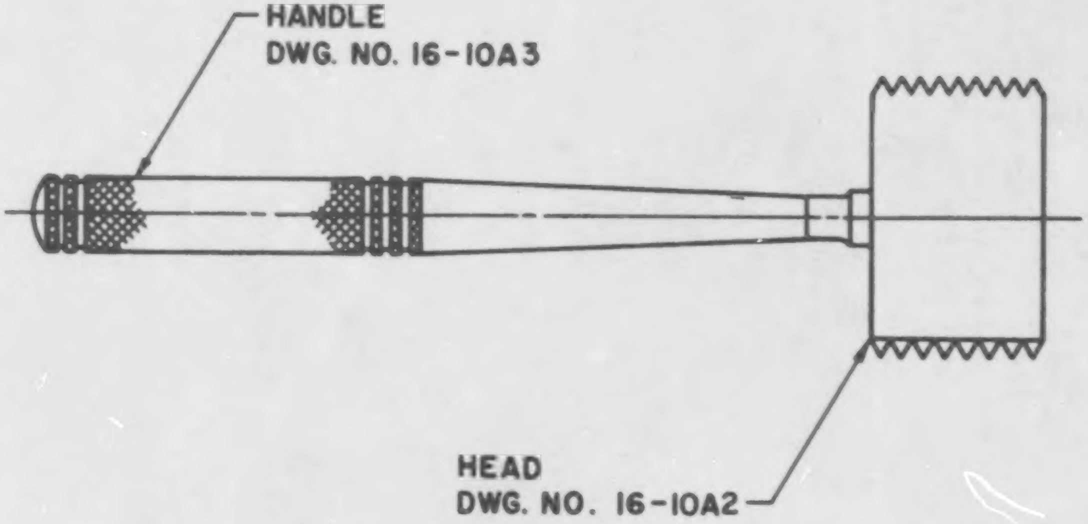
JACK SCREW-SWIVEL

SHEET 5 OF 5

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ±1/64
DECIMAL DIMENSIONS ±.005
ANGULAR DIMENSIONS ±1/2

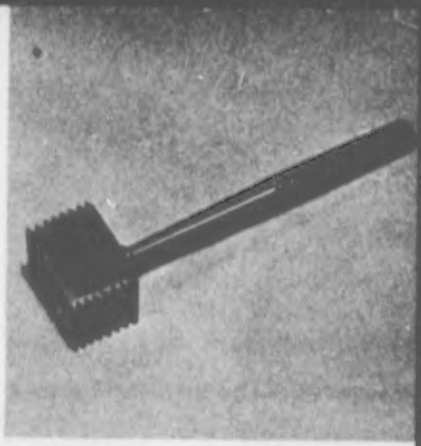
DRAWING NUMBER
15-10A5

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY


HANDLE
DWG. NO. 16-10A3
HEAD
DWG. NO. 16-10A2

SCALE: ½" = 1"	APPROVED BY:	DRAWN BY D.G.H
DATE: 8-14-70		REVISED
MEAT TENDERIZER - ASSEMBLY		
SHEET 1 OF 3	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ±1 2	DRAWING NUMBER 16-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



JOB SHEET

Job No. J-16-10-32   Drawing No. 16-10A2

MEAT TENDERIZER - HEAD

EQUIPMENT: Power cutoff saw, drill press, and shaper.

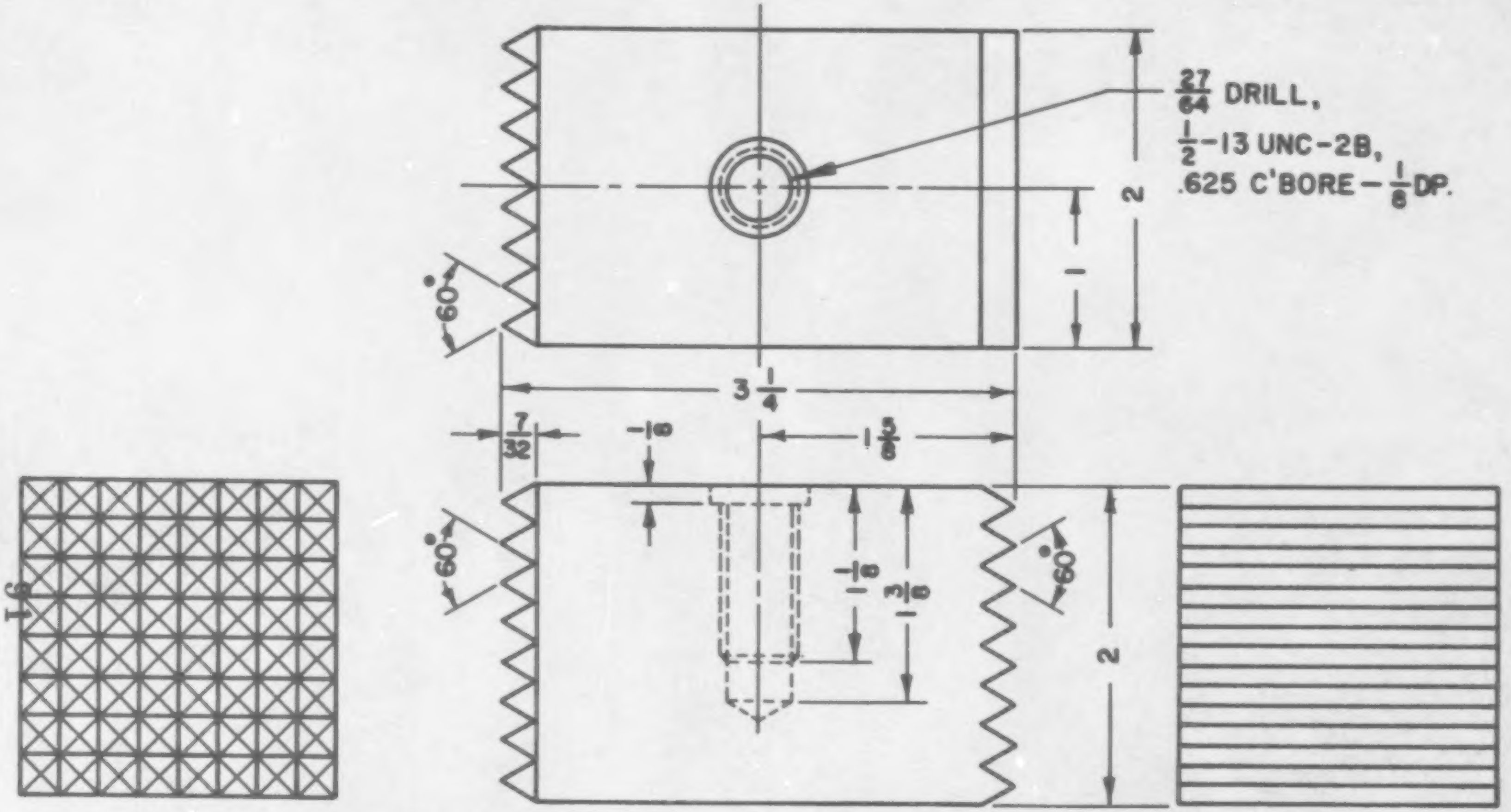
TOOLS:
scriber
file card
layout dye
prick punch
27/64" drill
center punch
layout hammer
5/8" counterbore
10" mill file
1/2"-13 N.C. tap set
combination square set

SAFETY PRECAUTIONS:

1. Never stand in front of a shaper while it is in motion.
2. Do not allow excessive overhang of toolholder.
3. Be careful not to get caught between the tool and the work piece.

PROCEDURE:

1. Select specified size of aluminum and cut to rough length on power cutoff saw.
2. Mount work piece in shaper vise.
3. Shape ends square and to required length.
4. Remove all burrs.
5. Layout serration guide lines.
6. Remount work piece in shaper vise.
7. Shape straight serrations on one end.
8. Shape cross serrations on opposite end.
9. Layout location for tapped hole.
10. Drill hole for 1/2"-13 N.C. tap.
11. Counterbore hole as per print.
12. Tap hole 1/2"-13 N.F.
13. Draw file all four sides.
14. Inspect as per print.



$\frac{27}{64}$ DRILL,
$\frac{1}{2}$-13 UNC-2B,
.625 C'BORE – $\frac{1}{8}$ DP.
2
1
$3\frac{1}{4}$
$\frac{7}{32}$
$\frac{1}{8}$
$1\frac{5}{8}$
$1\frac{1}{8}$
$1\frac{3}{8}$
2
60°
60°
60°

MATERIAL – SAE STD. NO. 26 ALUMINUM

SCALE: 1" = 1"	APPROVED BY:	DRAWN BY D.G.H.	
DATE: 8-13-70		REVISED	
MEAT TENDERIZER-HEAD			
SHEET 3 OF 3	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ±1/64 DECIMAL DIMENSIONS ±.005 ANGULAR DIMENSIONS ±1/2°	DRAWING NUMBER 16-10A2	

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION–THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-16-10-33 Drawing No. 16-10A3

MEAT TENDERIZER - HANDLE

EQUIPMENT: Power cutoff saw and lathe.

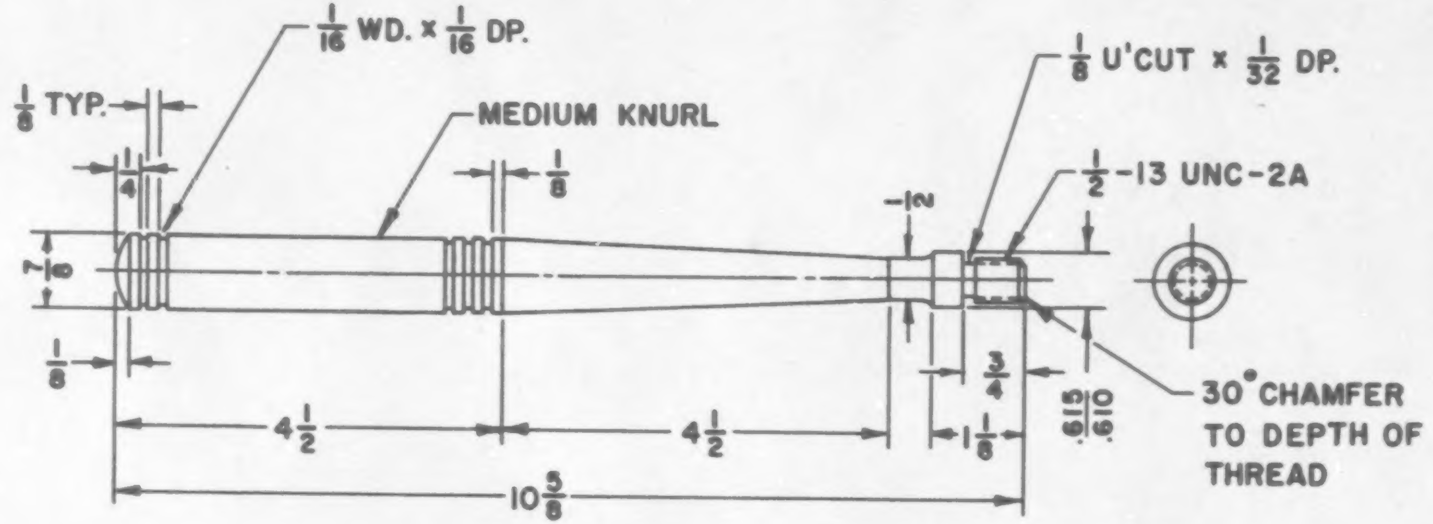
TOOLS:
- file card
- lathe dog
- center gauge
- screw-pitch gauge
- knurling tool
- abrasive cloth
- #3 center drill
- lathe collet set
- 10" mill file
- 60° threading tool
- 1/16" necking tool
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Keep cleaning and coolant brushes clear of work when knurling.
2. Always be aware of the direction of travel and speed of the carriage before engaging automatic feed.

PROCEDURE:

1. Select and cut on power cutoff saw the specified size of aluminum allowing material for center removal.
2. Mount work piece in lathe.
3. Face and center drill each end.
4. Mount work piece between centers.
5. Turn 7/8" diameter to lathe dog.
6. Knurl 7/8" diameter 4-3/4" long.
7. Turn 5 grooves 1/16" wide by 1/16" deep.
8. Reverse work piece.
9. Turn .615" diameter 1-1/8" long.
10. Turn thread diameter.
11. Chamfer 30° to thread depth.
12. Form undercut for thread relief.
13. Chase 1/2"-13 N.C. threads.
14. Turn taper using offset tailstock method (refer to Operation Sheet No. SL-1-13).
15. Turn 1/2" diameter between taper and .615" diameter.
16. Mount work piece in collet, handle end exposed.
17. Remove center at knurled end of handle.
18. Form radius on end of handle.
19. Polish with abrasive cloth.
20. Inspect as per print.


1/16 WD. x 1/16 DP.
1/8 TYP.
MEDIUM KNURL
1/4
1/8
7/8
1/8
4 1/2
4 1/2
10 5/8
1/2
1/8 U'CUT x 1/32 DP.
1/2-13 UNC-2A
3/4
1 1/8
.615
.610
30° CHAMFER TO DEPTH OF THREAD

MATERIAL - SAE STD. NO. 26 ALUMINUM

SCALE: 1/2" = 1"
DATE: 8-14-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

MEAT TENDERIZER-HANDLE

SHEET 2 OF 3

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
16-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-17-10-34 Drawing No. 17-10A1

LATHE CENTERS

EQUIPMENT: Lathe, tool post grinder, heat treating furnace, and power cutoff saw.

TOOLS:
- tongs
- scriber
- file card
- lathe dog
- layout dye
- cutting oil
- center gauge
- 12" steel rule
- parting blade and holder
- #3 center drill
- asbestos gloves
- abrasive cloth
- #2 Morse tapered drill sleeve
- 1/16" necking tool
- 10" mill file
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle
- 0-1" micrometer

SAFETY PRECAUTIONS:

1. When using tool post grinder make sure the work piece always turns in the opposite direction to that of the grinding wheel at the point of contact.
2. Keep face away from opening when lighting heat treating furnace.

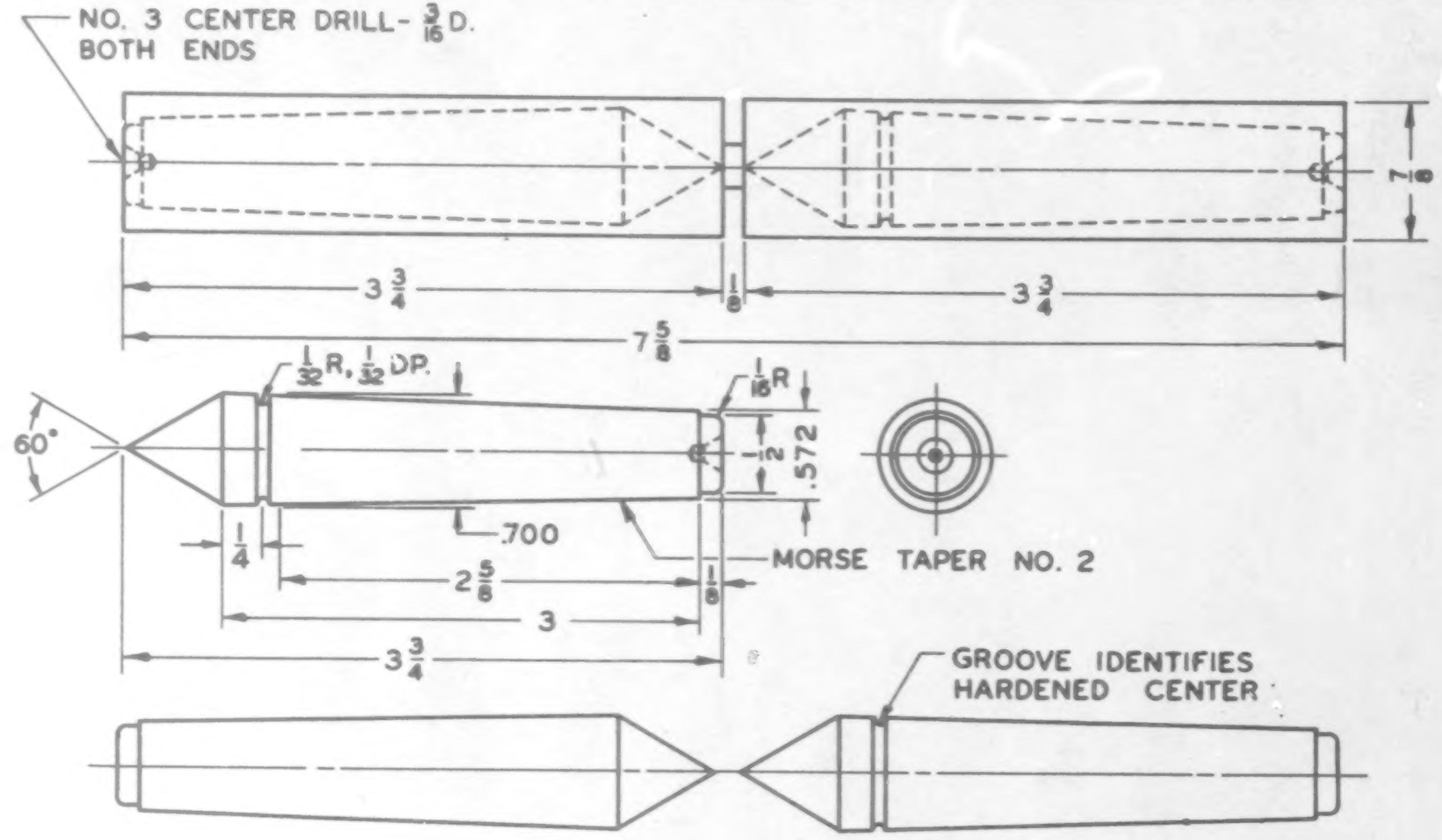
PROCEDURE:

1. Select drill rod and saw to rough length on power cutoff saw.
2. Mount work piece in lathe chuck.
3. Face and center drill each end.
4. Mount work piece between centers.
5. Adjust taper attachment to turn a #2 Morse taper (refer to Operation Sheet No. SL-1-27).
6. Rough turn taper.
7. Test taper by fitting with a #2 Morse taper drill sleeve.
8. Take second cut and test as before. Repeat until the correct taper is attained.
9. Finishing turning taper, then polish with abrasive cloth.
10. Form groove as per print in one center for identification of hardness.
11. Reverse work piece between centers.
12. Finish turn taper on other end and polish with abrasive cloth.
13. Set up lathe for straight turning.
14. Undercut both ends for clearance at small end of taper and form radius by filing.

15. Layout location of 1/8" groove at the center of the stock.
16. Mount one tapered end in spindle and part the centers.
17. Adjust compound rest to turn center points.
18. Turn angles on center points. Check accuracy of angle with center gauge.

    NOTE: Allow .010 for finish grinding 60° point.

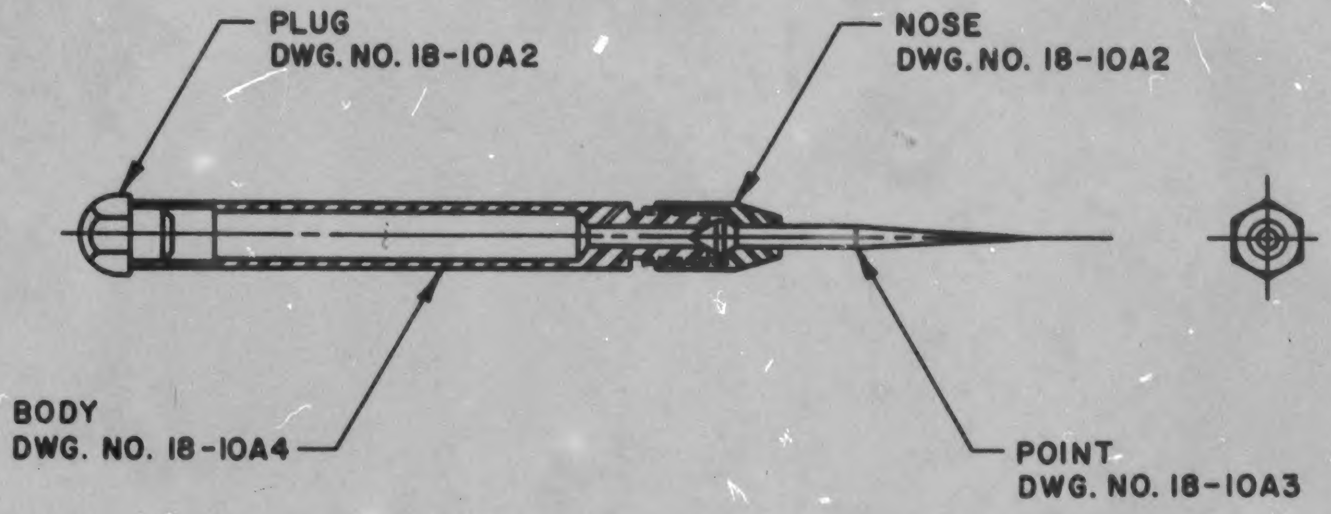
19. Harden and temper center identified by groove.
20. Set up tool post grinder (refer to Operation Sheet No. SL-1-28).
21. Grind 60° points on both centers
22. Inspect as per print.


NO. 3 CENTER DRILL- 3/16 D.
BOTH ENDS
7/8
3 3/4
1/8
3 3/4
7 5/8
1/32 R, 1/32 DP.
1/16 R
60°
1/2
.572
.700
MORSE TAPER NO. 2
1/4
2 5/8
1/8
3
3 3/4
GROOVE IDENTIFIES
HARDENED CENTER

MATERIAL - DRILL ROD AISI TYPE O2
(OIL HARDENING)
HEAT TREATMENT - HARDEN AND TEMPER

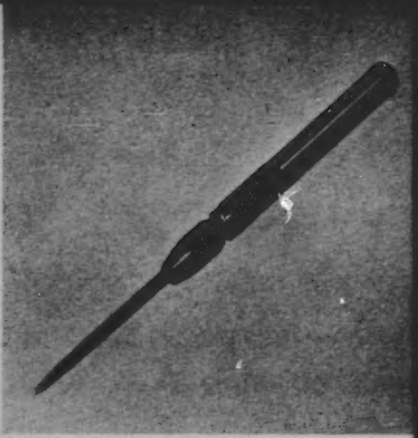
SCALE: 1 = 1 DATE: 12-30-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
LATHE CENTERS		
SHEET 1 OF 1	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2	DRAWING NUMBER 17-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY


PLUG
DWG. NO. 18-10A2
NOSE
DWG. NO. 18-10A2
BODY
DWG. NO. 18-10A4
POINT
DWG. NO. 18-10A3

SCALE: 1" = 1"	APPROVED BY:	DRAWN BY D. G. H.
DATE: 11-14-70		REVISED
SCRIBER - ASSEMBLY		
SHEET 1 OF 4	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2	DRAWING NUMBER 18-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



JOB SHEET

Job No. J-18-10-35 Drawing No. 18-10A2

SCRIBER - NOSE

EQUIPMENT: Lathe

TOOLS:
- file card
- "I" drill (.272)
- 1/8" reamer
- 7/64" drill
- parting blade and holder
- knurling tool
- 6" steel rule
- 60° countersink
- "I" flat bottom drill (.272)
- #2 center drill
- lathe collet set
- 5/16"-24 N.F. tap set
- 10" mill file
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Never try to remove chips from drills with your fingers.
2. Reduce spindle speed by 1/3 when reaming.

PROCEDURE:

1. Mount a length of 3/8" C.R. steel in chuck.
2. Face end and center drill.
3. Support material with center and knurl.
4. Drill 7/64" hole 3/4" deep.
5. Drill "I" hole 5/16" deep measuring from the point of the drill.
6. Size hole with "I" flat bottom drill to depth as per print.
7. Countersink 7/64" dia. hole 1/32" x 60° as per print. (Use #2 center drill.)
8. Tap hole with 5/16"-24 N.F. bottom tap (refer to Operation Sheet No. SL-1-21).
9. Ream 7/64" hole with 1/8" reamer.

   NOTE: Always use lubricant when reaming.

10. Part work piece allowing 1/64" to face.
11. Mount work piece in collet and face.
12. Set compound rest to 15° and turn taper.
13. Break all sharp edges.
14. Inspect as per print.

JOB SHEET

Job No. J-18-10-36

Drawing No. 18-10A2

SCRIBER - PLUG

EQUIPMENT: Lathe

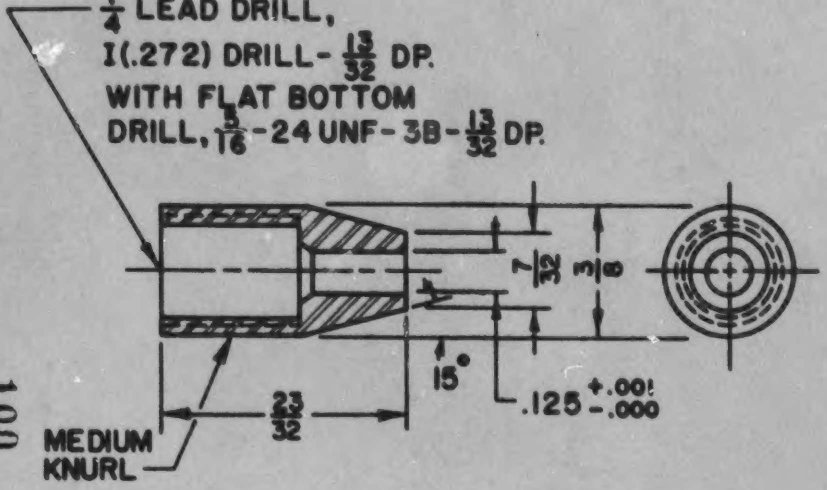
TOOLS:
- file card
- cutting oil
- hand hacksaw
- 6" steel rule
- abrasive cloth
- 0-1" micrometer
- 10" mill file
- 7/32" radius gauge
- left hand toolholder
- right hand facing tool
- right hand turning tool

SAFETY PRECAUTIONS:

1. It is dangerous practice to leave a chuck wrench in the chuck--even for a moment.
2. Be sure there is ample clearance for cutting operations that require working close to the chuck.

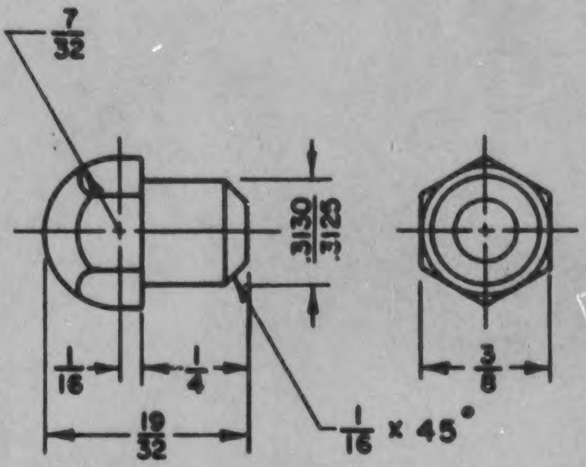
PROCEDURE:

1. Mount a length of 3/8" C.R. steel in chuck and face end.
2. Turn 5/16" diameter for press fit in scriber body. NOTE TOLERANCE!
3. Turn 1/16" x 45° chamfer on end to facilitate pressing.
4. Remove all burrs and cut to rough length with hand hacksaw.
5. Reverse work piece in chuck and turn radius according to print.
6. Polish with abrasive cloth.
7. Inspect as per print.



$\frac{1}{4}$ LEAD DRILL,
I(.272) DRILL- $\frac{13}{32}$ DP.
WITH FLAT BOTTOM
DRILL, $\frac{5}{16}$-24 UNF-3B- $\frac{13}{32}$ DP.
$\frac{7}{32}$
$\frac{3}{8}$
15°
.125 $^{+.001}_{-.000}$
$\frac{23}{32}$
MEDIUM
KNURL

NOSE



$\frac{7}{32}$
.3130
.3125
$\frac{1}{16}$
$\frac{1}{4}$
$\frac{19}{32}$
$\frac{1}{16}$ x 45°
$\frac{3}{8}$

PLUG

MATERIAL - NOSE- AISI-1018 C.R.S.
- PLUG- AISI-1018 C.R.S. HEX STOCK

SCALE: 2" = 1"
DATE: 11-13-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

SCRIBER-DETAILS

SHEET 2 OF 4

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2

DRAWING NUMBER
18-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-18-10-37

Drawing No. 18-10A3

SCRIBER - POINT

EQUIPMENT: Lathe

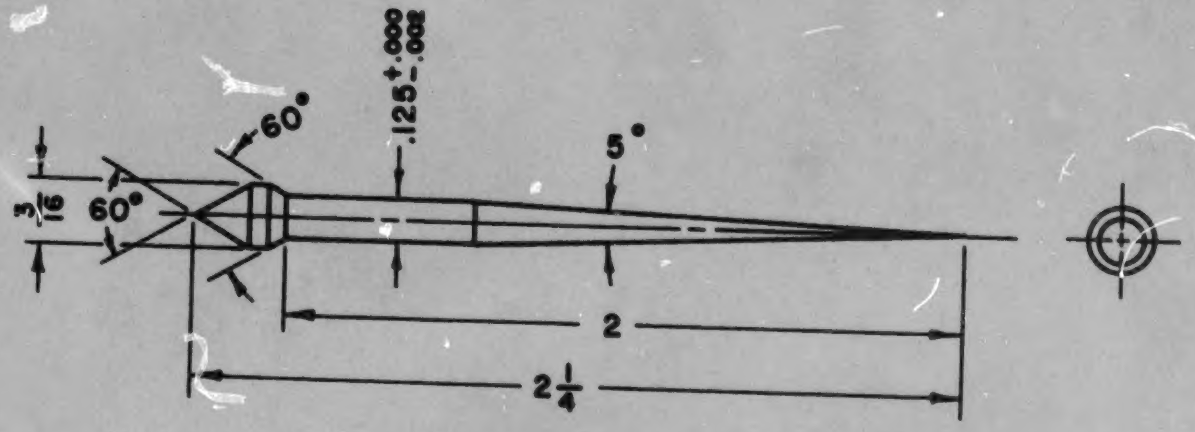
TOOLS:
- tongs
- cutting oil
- 6" steel rule
- hand hacksaw
- abrasive cloth
- asbestos gloves
- #2 center drill
- 0-1" micrometer
- lathe collet set
- 6" mill file
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. It is unsafe to have small diameter work extend more than an inch or two from the chuck or collet unless it is supported by the tailstock center.
2. Keep file clear of collets and chuck jaws.

PROCEDURE:

1. Mount 3/16" drill rod in collet, face, and center drill.
2. Extend material to 2-1/4" and support with center.
3. Turn 1/8" diameter and 60° angle.
4. Adjust compound rest to turn 5° angle.
5. Rough turn 5° angle.
6. Saw off center with hand hacksaw.
7. Finish file 5° angle.
8. Polish with abrasive cloth.
9. Reverse work piece in collet.
10. Saw to length.
11. Turn 60° angle on end.
12. Heat treat as per print.
13. Repolish with abrasive cloth.
14. Inspect as per print.



MATERIAL - DRILL ROD   AISI TYPE 02

SCALE: 2" = 1"
DATE: 11-13-70
APPROVED BY:
DRAWN BY D. G. H.
REVISED

SCRIBER - POINT

SHEET 3 OF 4
UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2
DRAWING NUMBER
18-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-18-10-38

Drawing No. 18-10A4

SCRIBER - BODY

EQUIPMENT: Lathe

TOOLS:
- file card
- 1/8" drill
- cutting oil
- hand hacksaw
- 5/16" reamer
- 19/64" drill
- screw-pitch gauge
- center gauge
- 6" steel rule
- knurling tool
- #3 center drill
- 60° countersink
- abrasive cloth
- 0-1" micrometer
- 60° threading tool
- 10" mill file
- 3/32" necking tool
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

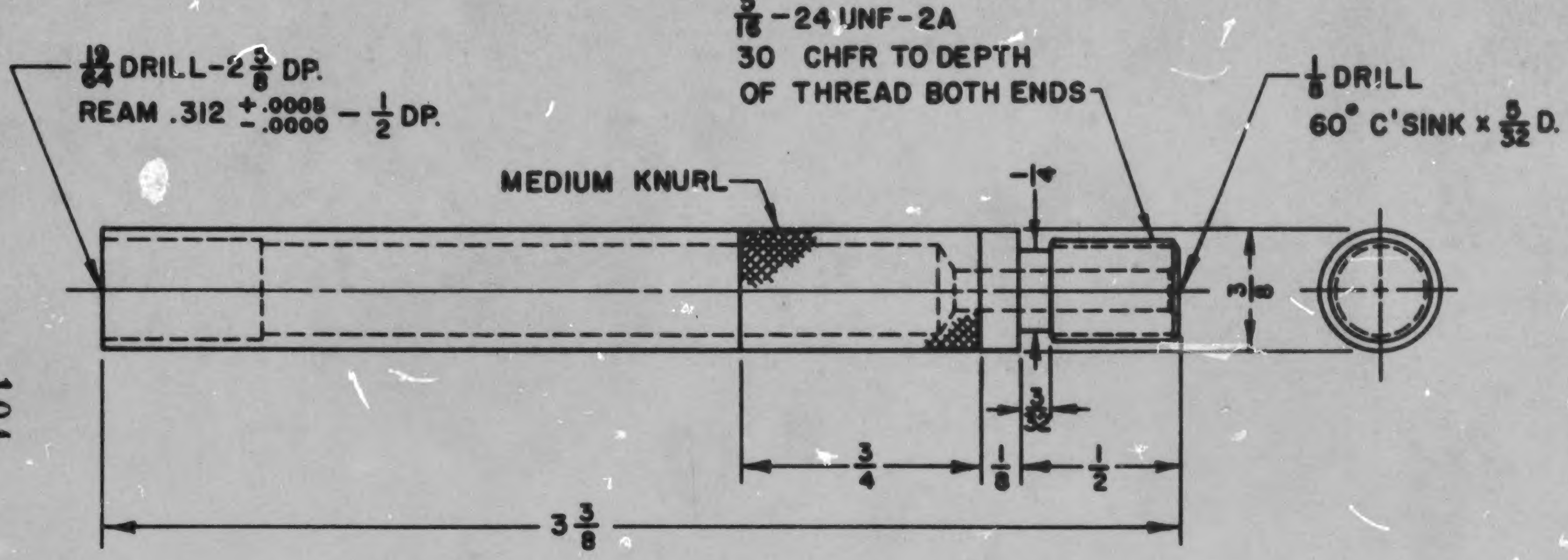
1. Always make sure your work is mounted securely in the chuck or collet.
2. Do not put excessive pressure on work piece with tailstock center.

PROCEDURE:

1. Select and cut 3/8" C.R. steel with hand hacksaw.
2. Mount work piece in chuck.
3. Face and center drill one end.
4. Support end with center.
5. Knurl as per print.
6. Turn 5/16" thread diameter.
7. Chamfer 30° to thread depth.
8. Form neck at shoulder end of thread diameter.
9. Chase 5/16"-24 N.F. thread to fit scriber nose.
10. Drill 1/8" hole through work piece.
11. Countersink 1/8" hole to 5/32" diameter with 60° countersink.
12. Reverse work piece in chuck.
13. Face to length.
14. Drill 19/64" hole.
15. Ream hole with 5/16" reamer as per print.

    NOTE: Keep the reamer lubricated.

16. Polish smooth surfaces with abrasive cloth.
17. Inspect as per print.


19/64 DRILL-2 5/8 DP.
REAM .312 +.0005 -.0000 - 1/2 DP.
5/16 -24 UNF-2A
30 CHFR TO DEPTH
OF THREAD BOTH ENDS
1/8 DRILL
60° C'SINK × 5/32 D.
MEDIUM KNURL
1/4
3/8
3/32
3/4
1/8
1/2
3 3/8

MATERIAL - AISI-1018 C.R.S.

SCALE: 2" = 1" DATE: 11-13-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
	SCRIBER - BODY	
SHEET 4 OF 4	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2	DRAWING NUMBER 18-10A4

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-19-10-39 Drawing No. 19-10A1

PLUMB BOB

EQUIPMENT: Power cutoff saw, lathe, and drill press.

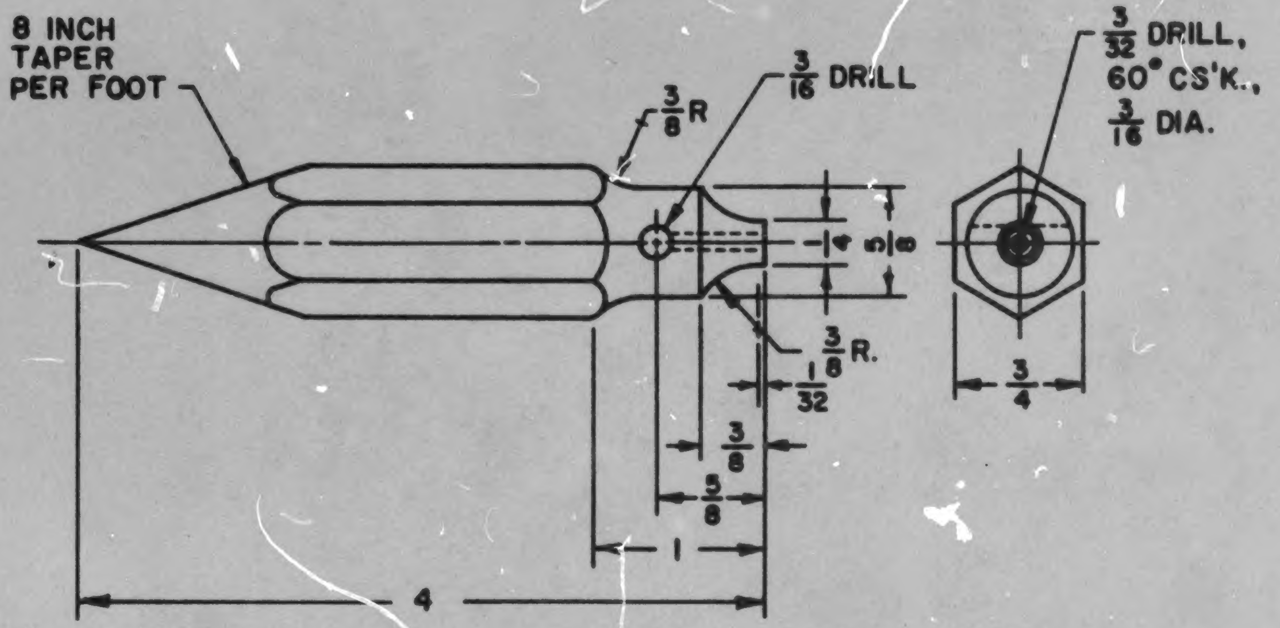
TOOLS:
scriber
file card
layout dye
cutting oil
3/16" drill
3/32" drill
prick punch
center punch
6" steel rule
layout hammer
abrasive cloth
#2 center drill
3/8" radius gauge
10" mill file
left hand toolholder
right hand facing tool
right hand turning tool
Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Observe safety rules for machine tools.
2. Be careful of every move you make.

PROCEDURE:

1. Select and cut 3/4" hex C.R. steel on power cutoff saw.
2. Mount work piece in chuck.
3. Face first end and center drill as per print.
4. Support extended with center.
5. Drill 3/32" hole.
6. Turn 5/8" diameter and 3/8" radius.
7. Turn 1/4" diameter and 3/8" radius.
8. Polish machined areas with abrasive cloth.
9. Reverse work piece in chuck.
10. Adjust compound rest to turn point.
11. Turn point.
12. Polish point with abrasive cloth.
13. Layout location of 3/16" hole.
14. Drill 3/16" hole
15. Inspect as per print.


8 INCH
TAPER
PER FOOT
3/8 R
3/16 DRILL
3/32 DRILL,
60° CS'K.,
3/16 DIA.
1/4
5/8
3/8 R.
1/32
3/8
5/8
1
4
3/4

MATERIAL- AISI -1018 C.R.S.

SCALE: 1" = 1"
DATE: 8-13-70
APPROVED BY:
DRAWN BY
REVISED

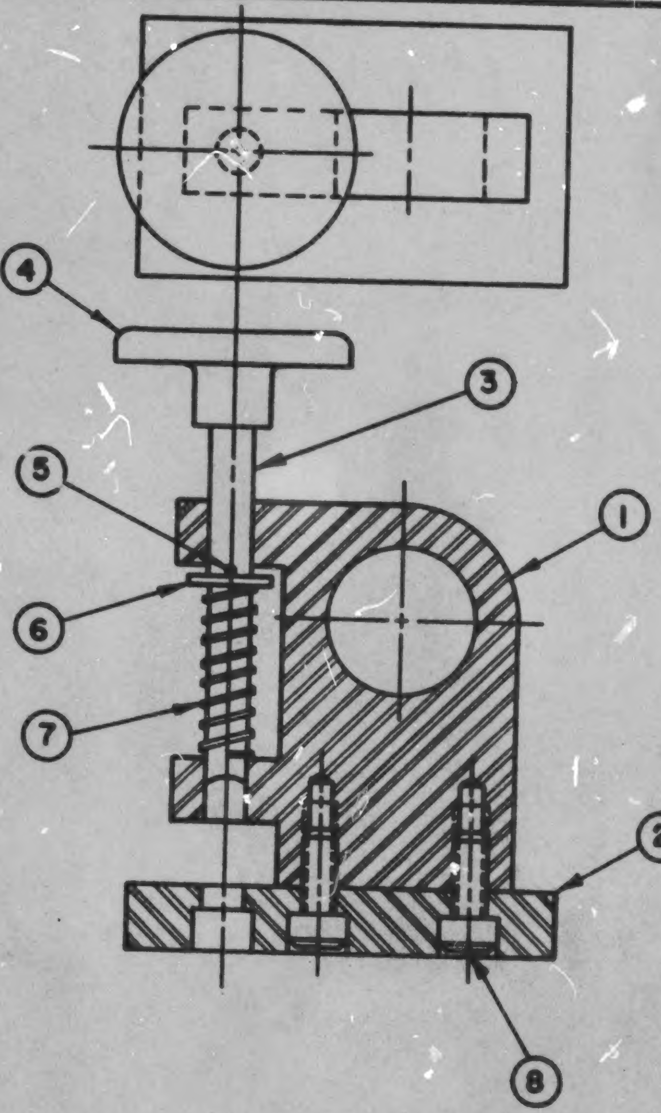
PLUMB BOB

SHEET 1 OF 1

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2

DRAWING NUMBER
19-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



DET.	QTY.	PART NAME	MATERIAL	SHEET NO.
8	2	FILLISTER HD. SCR.	10-32 x 1/2 LG.	
7	1	SPRING	STOCK	
6	1	FLAT WASHER	9/32 I.D. x 1/2 O.D. x 1/16	
5	1	DOWEL PIN	1/16 DIA. x 1/2 LG.	
4	1	CAP	AISI-1018 C.R.S.	20-10A5
3	1	PUNCH	DRILL ROD	20-10A4
2	1	BASE	AISI-1018 C.R.S.	20-10A3
1	1	BODY	AISI-1018 C.R.S.	20-10A2

SCALE: 1" = 1"
DATE: 11-14-70
APPROVED BY:
DRAWN BY D. G.H.
REVISED

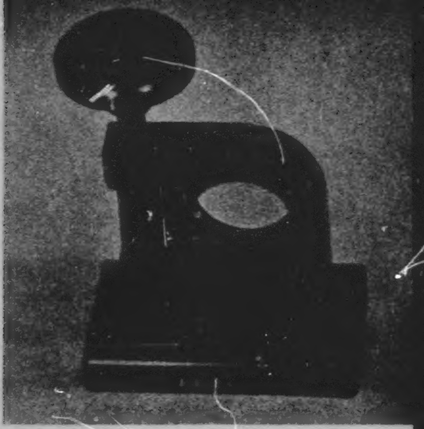
PAPER PUNCH - ASSEMBLY

SHEET 1 OF 5

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ±1/64
DECIMAL DIMENSIONS ±.005
ANGULAR DIMENSIONS ±1/2

DRAWING NUMBER
20-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



JOB SHEET

Job No. J-20-10-40 Drawing No. 20-10A2

PAPER PUNCH - BODY

EQUIPMENT: Power cutoff saw, vertical milling machine, and surface grinder.

TOOLS:
scriber
6" square
3/4" drill
1/4" drill
1/2" drill
layout dye
cutting oil
center punch
layout hammer
6" steel rule
82° countersink
#4 center drill
#21 drill (.159)
11/16" radius gauge
10" mill file
10-32 N.C. tap set
adjustable tap wrench
10" flat file
file card
prick punch

SAFETY PRECAUTIONS:

1. Never carry a scriber in your pocket.
2. Never strike a blow with a loose hammer head.

PROCEDURE:

1. Select and cut material to rough length on power cutoff saw.
2. Mount work piece in milling machine vise.
3. Mill ends to length.
4. Mount work piece on surface grinder.
5. Grind top and bottom surfaces to remove imperfections.
6. Layout work piece as per drawing.
7. Remount work piece in milling machine vise.
8. Mill out sections as per print.
9. Position table for machining 7/8" hole.

   NOTE: Be careful to remove end play in table positioning screws.

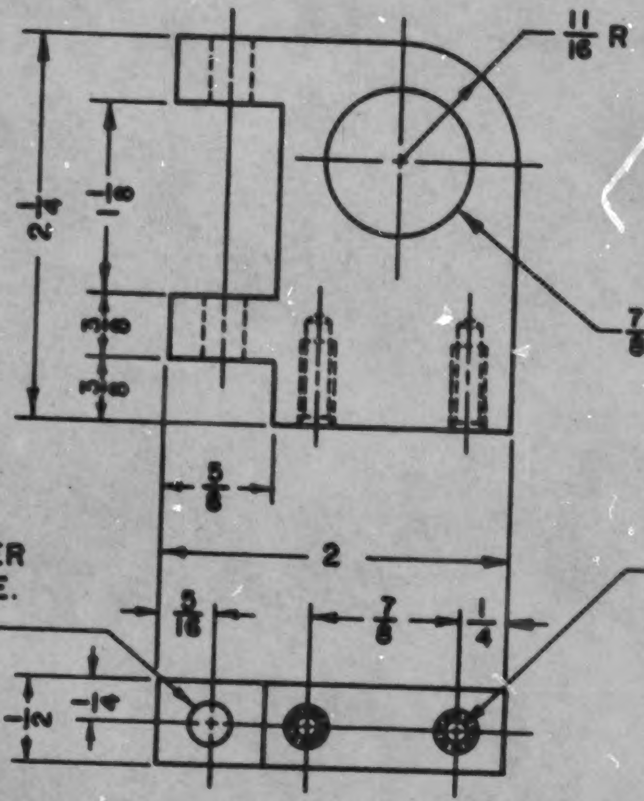
10. Center drill and drill progressively using 1/4", 1/2", and 3/4" drills (refer to Operation Sheet No. SL-4-3).
11. Finish bore 7/8" diameter hole (refer to Operation Sheet No. SL-4-15).
12. Rough file 11/16" radius.
13. Finish radius by draw filing.
14. Position table for drilling tapped holes. Begin with hole nearest vertical or back edge.

    NOTE: Remove end play from table screws.

15. Center drill and drill #21 hole.
16. Countersink 82° x 7/32" diameter.
17. Tap 10-32 N.C. thread using drill chuck to start tap straight. Finish by hand.
18. Position table for second hole by using graduated dial on table screw.

NOTE: Remove end play from table screws.

19. Repeat procedural steps 15, 16, and 17.
20. Break all sharp edges.
21. Inspect as per print.



15/64 LINE DRILL,
.250 LINE REAM AFTER
ASSEMBLY WITH BASE.
LAP TO FIT PUNCH.

NO 21 (.159) DRILL, 5/8 DP.,
82° C'SK., 7/32 DIA.,
10-32 UNF-2B, 1/2 DP.,
2 HOLES

MATERIAL - AISI - 1018 C.R.S.

SCALE: 1" = 1"
DATE: 11-14-70
APPROVED BY:
DRAWN BY
REVISED

PAPER PUNCH - BODY

SHEET 2 OF 5

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
20-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-20-10-41

Drawing No. 20-10A3

PAPER PUNCH - BASE

EQUIPMENT: Power cutoff saw, vertical milling machine, and surface grinder.

TOOLS:
- scriber
- file card
- 6" square
- parallels
- layout dye
- center punch
- prick punch
- 7/32" drill
- layout hammer
- 6" steel rule
- 11/32" counterbore
- 10" mill file

SAFETY PRECAUTIONS:

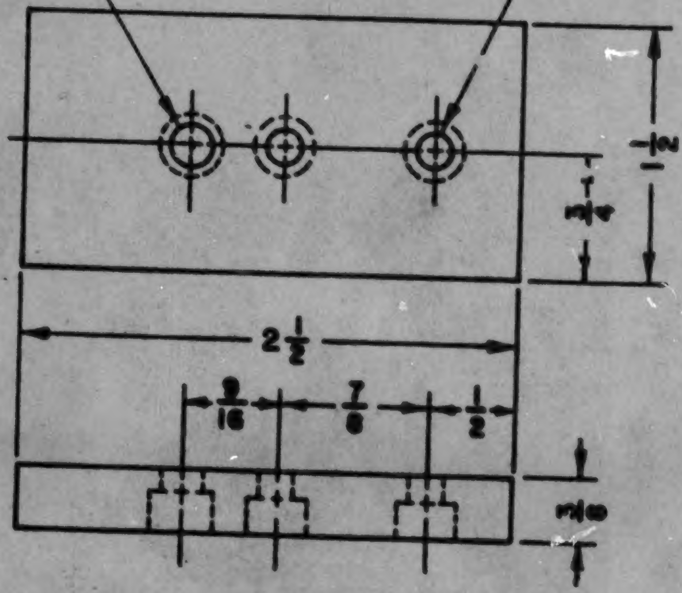
1. When using a prick or center punch, make sure point is sharp.
2. Never do any hammering on a surface plate.

PROCEDURE:

1. Select material and cut to rough length on power cutoff saw.
2. Mount work piece in milling machine vise.
3. Mill ends square and to length.
4. Mount work piece on surface grinder.
5. Grind top and bottom surfaces to remove imperfections.
6. Layout work piece as per drawing for two bolt holes.
7. Remount work piece on parallels in milling machine vise.
8. Locate rear punch mark being certain to remove all end play from table screw.
9. Center drill and drill 7/32" hole.
10. Counterbore 7/32" hole 7/32" deep (refer to Operation Sheet No. SL-4-6).
11. Move table the required distance to the next punch mark by using the graduated dial on the hand wheel.
12. Drill second 7/32" hole.
13. Counterbore as per print.
14. Break all sharp edges.
15. Inspect as per print.

$\frac{15}{64}$ LINE DRILL,
.250 LINE REAM AFTER
ASSEMBLY WITH BODY.
LAP TO FIT PUNCH.

$\frac{7}{32}$ DRILL, $\frac{11}{32}$ C'BORE - $\frac{7}{32}$ DP.,
2 HOLES



$1\frac{1}{2}$
$\frac{3}{4}$
$2\frac{1}{2}$
$\frac{9}{16}$
$\frac{7}{8}$
$\frac{1}{2}$
$\frac{3}{8}$

MATERIAL - AISI - 1018 C.R.S.

SCALE: 1" = 1"
DATE: 11-14-70
APPROVED BY:
DRAWN BY
REVISED

PAPER PUNCH - BASE

SHEET 3 OF 5

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
20-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-20-10-42

Drawing No. 20-10A4

PAPER PUNCH - PUNCH

EQUIPMENT: Lathe, heat treating furnace, and drill press.

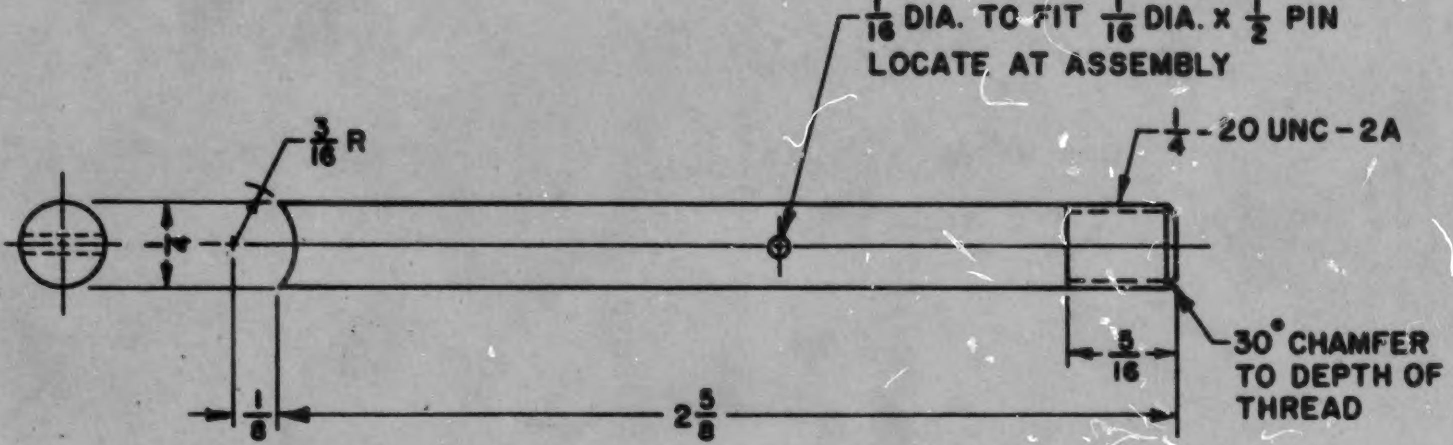
TOOLS:
- tongs
- layout dye
- 1/16" drill
- prick punch
- cutting oil
- center punch
- center gauge
- screw-pitch gauge
- hand hacksaw
- 6" steel rule
- layout hammer
- abrasive cloth
- asbestos gloves
- #0 center drill
- lathe collet set
- 3/16" radius gauge
- 60° threading tool
- 3/16" radius tool
- left hand toolholder
- right hand facing tool
- 10" mill file

SAFETY PRECAUTIONS:

1. Make sure the collet and work are securely fastened.
2. Avoid excessive overhang with tool and toolholder.

PROCEDURE:

1. Select and cut drill rod to length with hand hacksaw.
2. Mount work piece in collet and extend approximately 1/2".
3. Face end and chamfer 1/16" x 45°.
4. Chase 1/4"-20 N.C. thread to length. Fit to cap.
5. Reverse work piece in collet.
6. Form 3/16" concave radius.
7. Layout location of 1/16" hole.
8. Center drill and drill 1/16" hole.
9. Polish with abrasive cloth.
10. Heat treat.
11. Repolish with abrasive cloth.
12. Inspect as per print.



$\frac{1}{16}$ DIA. TO FIT $\frac{1}{16}$ DIA. x $\frac{1}{2}$ PIN
LOCATE AT ASSEMBLY
$\frac{3}{16}$ R
$\frac{1}{4}$-20 UNC-2A
$\frac{1}{4}$
30° CHAMFER
TO DEPTH OF
THREAD
$\frac{5}{16}$
$\frac{1}{8}$
$2\frac{5}{8}$

MATERIAL-DRILL ROD AISI TYPE O2

HEAT TREATMENT- HARDEN AND TEMPER

SCALE: 2" = 1" DATE: 11-14-70	APPROVED BY:	DRAWN BY REVISED
PAPER PUNCH-PUNCH		
SHEET 4 OF 5	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2	DRAWING NUMBER 20-10A4

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-20-10-43 Drawing No. 20-10A5

PAPER PUNCH - CAP

EQUIPMENT: Power cutoff saw and lathe.

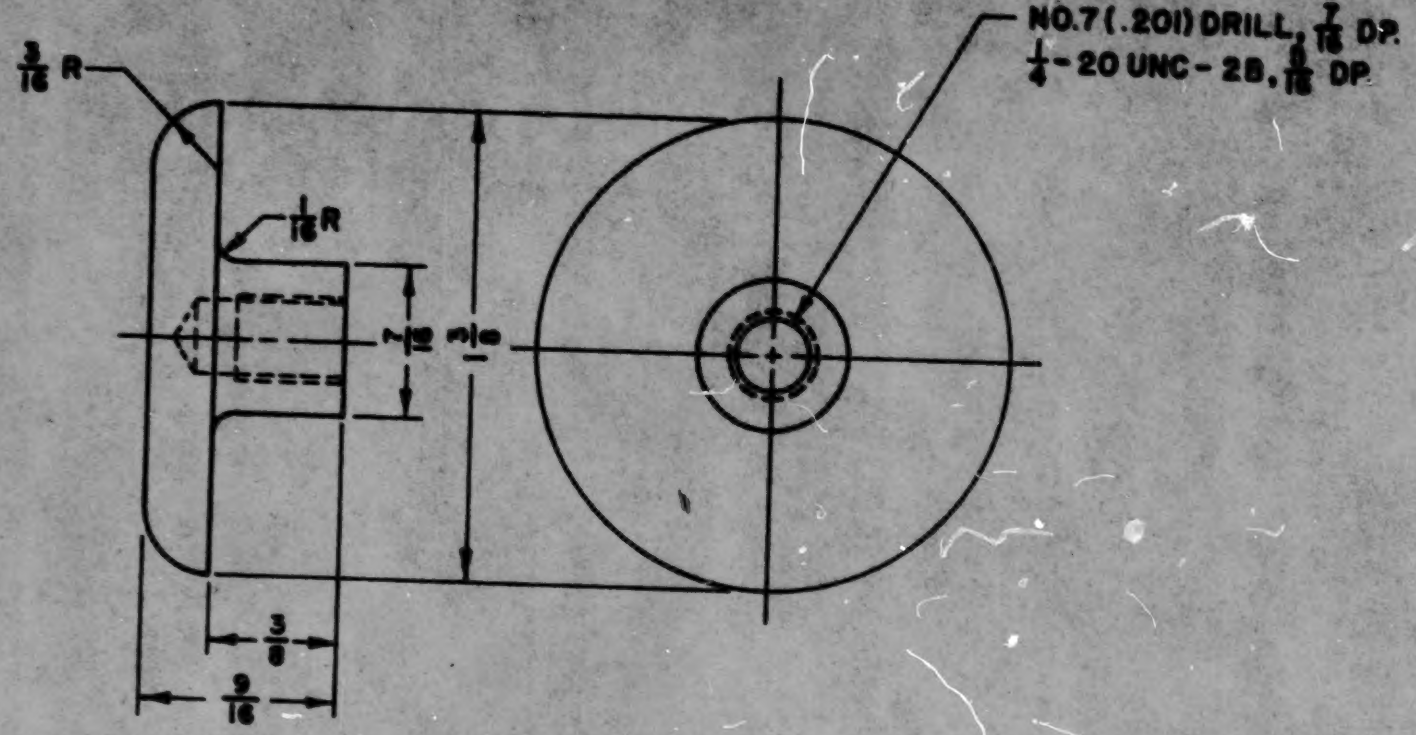
TOOLS:
- file card
- cutting oil
- 6" steel rule
- abrasive cloth
- #7 drill (.201)
- #4 center drill
- 1/4"-20 N.C. tap
- 3/16" radius gauge
- 10" mill file
- 1/16" radius gauge
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Always make certain your work is held securely when using chucks or collets.
2. Provide sufficient clearance between compound rest and chuck.

PROCEDURE:

1. Select and cut material 3/4" long on power cutoff saw.
2. Mount work piece in chuck.
3. Face end and center drill.
4. Drill #7 drill as per print.
5. Start tap, supported by center in tailstock.
6. Finish tapping by hand.
7. Turn 7/16" diameter.
8. Turn 1/16" radius.
9. Reverse work piece in chuck.
10. Face to length.
11. Turn 3/16" radius.
12. Break all sharp edges.
13. Polish with abrasive cloth.
14. Inspect as per print.


NO.7 (.201) DRILL, 7/16 DP.
1/4 - 20 UNC - 2B, 5/16 DP.
3/16 R
1/16 R
7/16
1 3/8
3/8
9/16

MATERIAL - AISI - 1018 C.R.S.

SCALE: 2" = 1" DATE: 11-14-70	APPROVED BY:	DRAWN BY D.G.H. REVISED

PAPER PUNCH-CAP

SHEET 5 OF 5	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ± 1/64 DECIMAL DIMENSIONS ± .005 ANGULAR DIMENSIONS ± 1/2°	DRAWING NUMBER 20-10A5

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-20-10-44 Drawing No. 20-10A1

ASSEMBLY OF PAPER PUNCH

EQUIPMENT: Vertical milling machine.

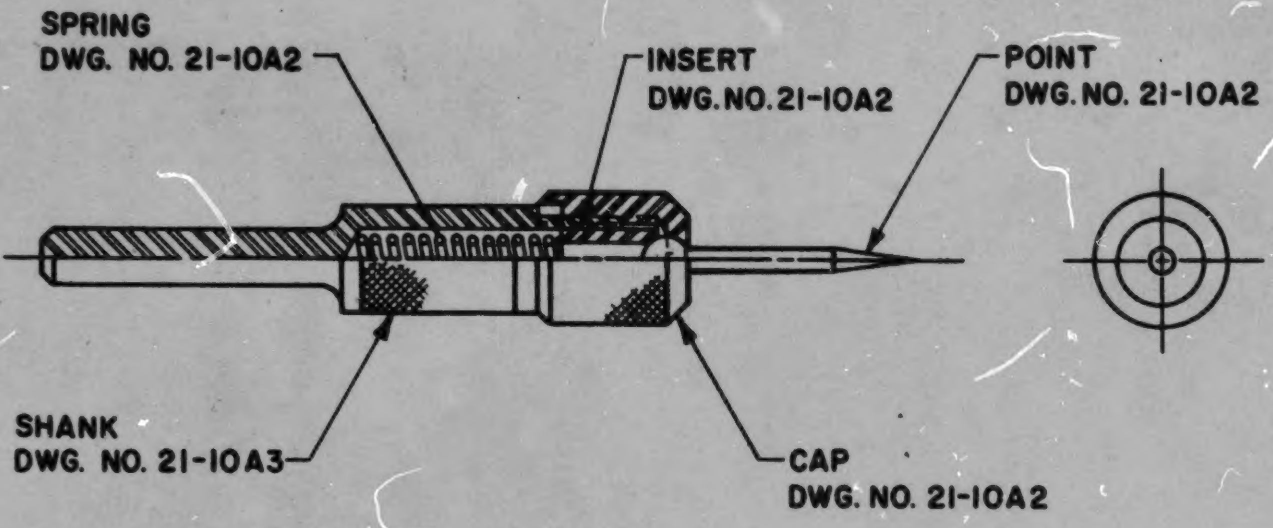
TOOLS:
- scriber
- layout dye
- 1/4" reamer
- cutting oil
- prick punch
- center punch
- 15/64" drill
- 6" steel rule
- center finder
- layout hammer
- 1/2" parallels
- abrasive cloth
- #3 center drill
- 11/32" counterbore

SAFETY PRECAUTIONS:

1. Remove all chips and burrs.
2. Use care when polishing with abrasive cloth held in hand.

PROCEDURE:

1. Assemble body and base.
2. Layout assembly as per Drawing No. 20-10A2 in order to machine hole for punch.
3. Prick punch.
4. Mount assembly on milling machine table, using 1/2" parallels to insure against table damage.
5. Locate prick punch mark with center finder.
6. Center drill prick punch mark.
7. Drill 15/64" hole through entire assembly.
8. Ream 1/4" hole (refer to Operation Sheet No. SL-4-7).
9. Counterbore reamed hole from underside of base as per Drawing No. 20-10A3.
10. Assemble cap with punch and check for fit with body and base. Some polishing of punch may be required to insure a desireable fit.
11. Final inspection requires the addition of a spring over the punch and pinned into place.


SPRING
DWG. NO. 21-10A2
INSERT
DWG.NO.21-10A2
POINT
DWG.NO. 21-10A2
SHANK
DWG. NO. 21-10A3
CAP
DWG. NO. 21-10A2

SCALE: 1" = 1"
DATE: 11-21-70
APPROVED BY:
DRAWN BY D. G. H.
REVISED

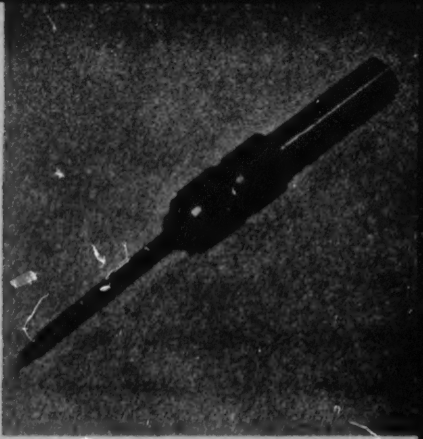
CENTER FINDER-ASSEMBLY

SHEET 1 OF 3

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ±1 2

DRAWING NUMBER
21-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



JOB SHEET

Job No. J-21-10-45 Drawing No. 21-10A2

CENTER FINDER - CAP

EQUIPMENT: Lathe and power cutoff saw.

TOOLS:

file card
1/4" drill
cutting oil
3/16" drill
29/64" drill
knurling tool
6" steel rule
#2 center drill
60° countersink
0-1" micrometer
lathe collet set
41/64" counterbore
10" mill file
1/2"-20 N.F. tap set
left hand toolholder
adjustable tap wrench
right hand facing tool
Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Stop the machine before making measurements or adjustments.
2. Do not run knurling tool into chuck jaws.

PROCEDURE:

1. Select a short piece of required material and mount it in the lathe collet.
2. Face and center drill one end.
3. Knurl 1" length.
4. Drill 3/16" hole to sufficient depth.
5. Drill 29/64" hole to specified depth and countersink.
6. Tap 1/2"-20 N.F.
7. Counterbore 41/64" to specified depth.
8. Turn 1/32" x 45° chamfer.
9. Saw off cap to rough length on power cutoff saw.
10. Remount work piece in collet.
11. Face to length.
12. Turn 1/8" x 45° chamfer and remove all burrs.
13. Inspect as per print.

JOB SHEET

Job No. J-21-10-46 Drawing No. 21-10A2

CENTER FINDER - BALL

EQUIPMENT: Lathe and heat treating furnace

TOOLS:
- tongs
- cutting oil
- 0-1" micrometer
- #2 center drill
- asbestos gloves
- lathe collet set
- #31 drill (.120)
- abrasive cloth
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle
- straight toolholder
- appropriate tool bits

SAFETY PRECAUTIONS:

1. When discontinuing operations on a heat treating furnace, always turn off gas supply first.

PROCEDURE:

1. Select ball bearing as specified. Ball bearing can vary in size up to ten thousandths either larger of smaller.
2. Anneal the ball bearing in a non-oxidizing atmosphere to prevent scaling of the ball surface (refer to Operation Sheet No. SL-8-3).
3. Select and turn a short length of rod to exactly the same diameter as the ball. This bar is to be mounted along with the ball to serve as a back-up to prevent the ball from slipping through the collet due to the drilling pressure.
4. Mount ball and back-up bar in the collet and turn a small starting point for the center drill.
5. Center drill.
6. Drill required hole to size and depth specified.
7. Heat treat ball. Atmosphere surrounding ball should be controlled to eliminate scaling.
8. Remount ball in collet.
9. Mount point in Jacobs chuck mounted in tailstock and press blunt end into ball.
10. Reverse work in collet and polish ball with abrasive cloth.
11. Inspect as per print.

JOB SHEET

Job No. J-21-10-47 | Drawing No. 21-10A2

CENTER FINDER - POINT

EQUIPMENT: Lathe and heat treating furnace.

TOOLS:

tongs	hand hacksaw	asbestos gloves
file card	6" steel rule	lathe collet set
cutting oil	abrasive cloth	10" mill file

SAFETY PRECAUTIONS:

1. Care must be taken when hand sawing small diameter material; saw close to jaws at the bench vise.

PROCEDURE:

1. Select drill rod and cut to length using hand hacksaw.
2. Mount work piece in collet and file point according to specifications.
3. Use narrow strip of abrasive cloth to reduce diameter of blunt end for press fit into ball.
4. Polish with abrasive cloth.
5. Heat treat.
6. Inspect as per print.

JOB SHEET

Job No. J-21-10-48 Drawing No. 21-10A2

CENTER FINDER - INSERT

EQUIPMENT: Lathe

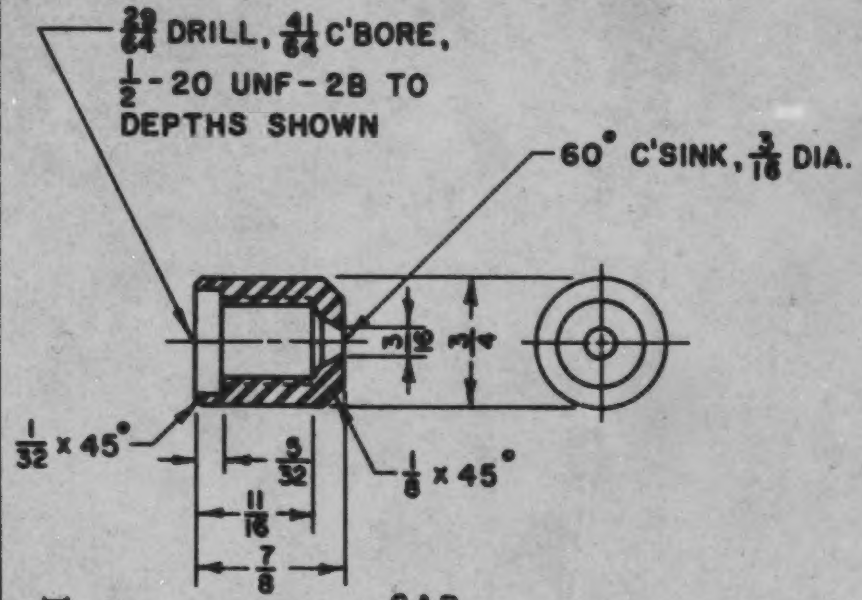
TOOLS:
- file card
- 3/16" drill
- cutting oil
- hand hacksaw
- 6" steel rule
- 60° countersink
- #2 center drill
- 0-1" micrometer
- 10" mill file
- left hand toolholder
- right hand facing tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

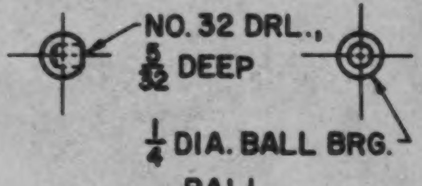
1. Check feed rates before turning on feed especially when working near the chuck.
2. Use extreme caution when filing near the chuck.

PROCEDURE:

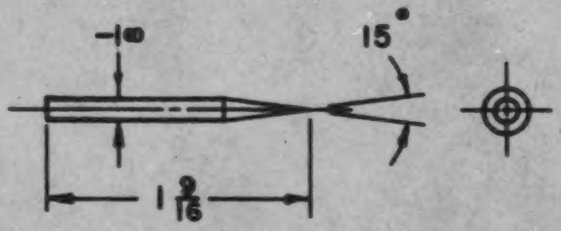
1. Select required material and cut to rough length using hand hacksaw.
2. Mount work piece in collet.
3. Face and center drill.
4. Drill 3/16" hole.
5. Countersink as per print.
6. Reverse work piece in collet.
7. Face to length.
8. Break all sharp edges.
9. Inspect as per print.


$\frac{29}{64}$ DRILL, $\frac{41}{64}$ C'BORE,
$\frac{1}{2}$-20 UNF-2B TO
DEPTHS SHOWN
60° C'SINK, $\frac{3}{16}$ DIA.
$\frac{3}{16}$
$\frac{3}{4}$
$\frac{1}{32}$ x 45°
$\frac{5}{32}$
$\frac{1}{8}$ x 45°
$\frac{11}{16}$
$\frac{7}{8}$

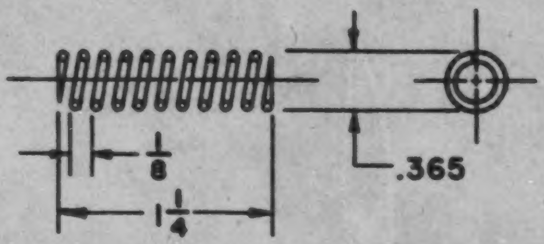
CAP


NO. 32 DRL., $\frac{5}{32}$ DEEP
$\frac{1}{4}$ DIA. BALL BRG.

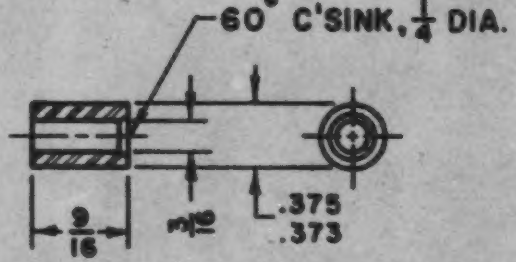
BALL


$\frac{1}{8}$
15°
$1\frac{9}{16}$

POINT


$\frac{1}{8}$
$1\frac{1}{4}$
.365

SPRING


60° C'SINK, $\frac{1}{4}$ DIA.
$\frac{9}{16}$
$\frac{3}{16}$
.375
.373

INSERT

HEAT TREATMENT - POINT - H'DN. AND TEMPER
- BALL - ANNEAL - MACHINE - PACK H'DN. AND TEMPER

MATERIAL - CAP - AISI - 1018 C.R.S.
- POINT - DRILL ROD - AISI TYPE 02
- SPRING - MUSIC WIRE - SAE - 1085
- INSERT - AISI - 1018 C.R.S.

SCALE: 1" = 1" DATE: 11-21-70	APPROVED BY:	DRAWN BY D.G.H. REVISED
CENTER FINDER-DETAILS		
SHEET 2 OF 3	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ±1/64 DECIMAL DIMENSIONS ±.006 ANGULAR DIMENSIONS ±1/2	DRAWING NUMBER 21-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-21-10-49

Drawing No. 21-10A3

CENTER FINDER - SHANK

EQUIPMENT: Lathe and power cutoff saw.

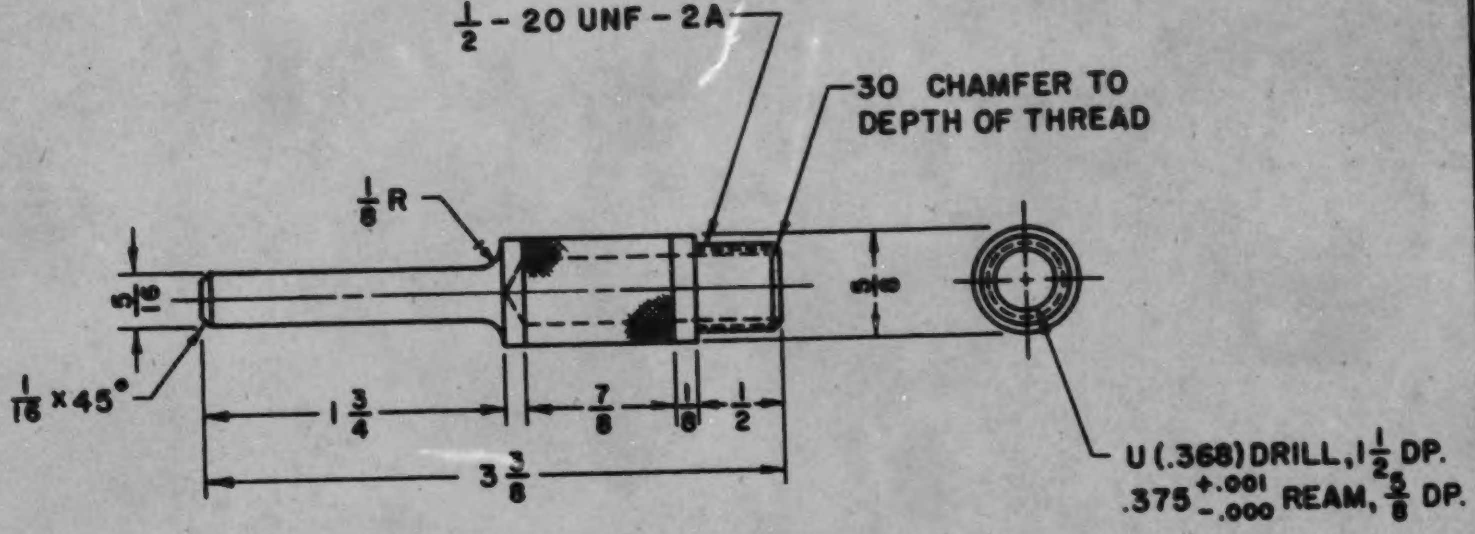
TOOLS:
- file card
- 1/4" drill
- cutting oil
- screw-pitch gauge
- knurling tool
- 6" steel rule
- abrasive cloth
- #2 center drill
- lathe collet set
- "U" drill (.368)
- 1/8" radius tool
- 10" mill file
- 60° threading tool
- 3/8" machine reamer
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Always determine the direction of carriage movement before engaging the automatic feed.
2. Do not use compressed air to remove chips from machine tools.

PROCEDURE:

1. Select required material and cut to rough length on power cutoff saw.
2. Mount work piece in collet and face end.
3. Turn 5/16" diameter.
4. Form 1/8" radius.
5. Turn 1/16" x 45° chamfer.
6. Reverse work piece in collet.
7. Face to length and center drill.
8. Support work piece with center and knurl as specified.
9. Turn thread diameter.
10. Chase 1/2"-20 N.F. thread and fit to cap.
11. Chamfer 30° to thread depth.
12. Drill "U" hole to specified depth.
13. Ream 3/8" hole 5/8" deep.
14. Break all sharp edges.
15. Polish with abrasive cloth.
16. Inspect as per print.


$\frac{1}{2}$ - 20 UNF - 2A
30 CHAMFER TO DEPTH OF THREAD
$\frac{1}{8}$ R
$\frac{5}{16}$
$\frac{1}{16}$ × 45°
$1\frac{3}{4}$
$\frac{7}{8}$
$\frac{1}{8}$
$\frac{1}{2}$
$3\frac{3}{8}$
$\frac{5}{8}$
U (.368) DRILL, $1\frac{1}{2}$ DP.
$.375^{+.001}_{-.000}$ REAM, $\frac{5}{8}$ DP.

MATERIAL - AISI-1018 C.R.S.

SCALE: 1" = 1"
DATE: 11-21-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

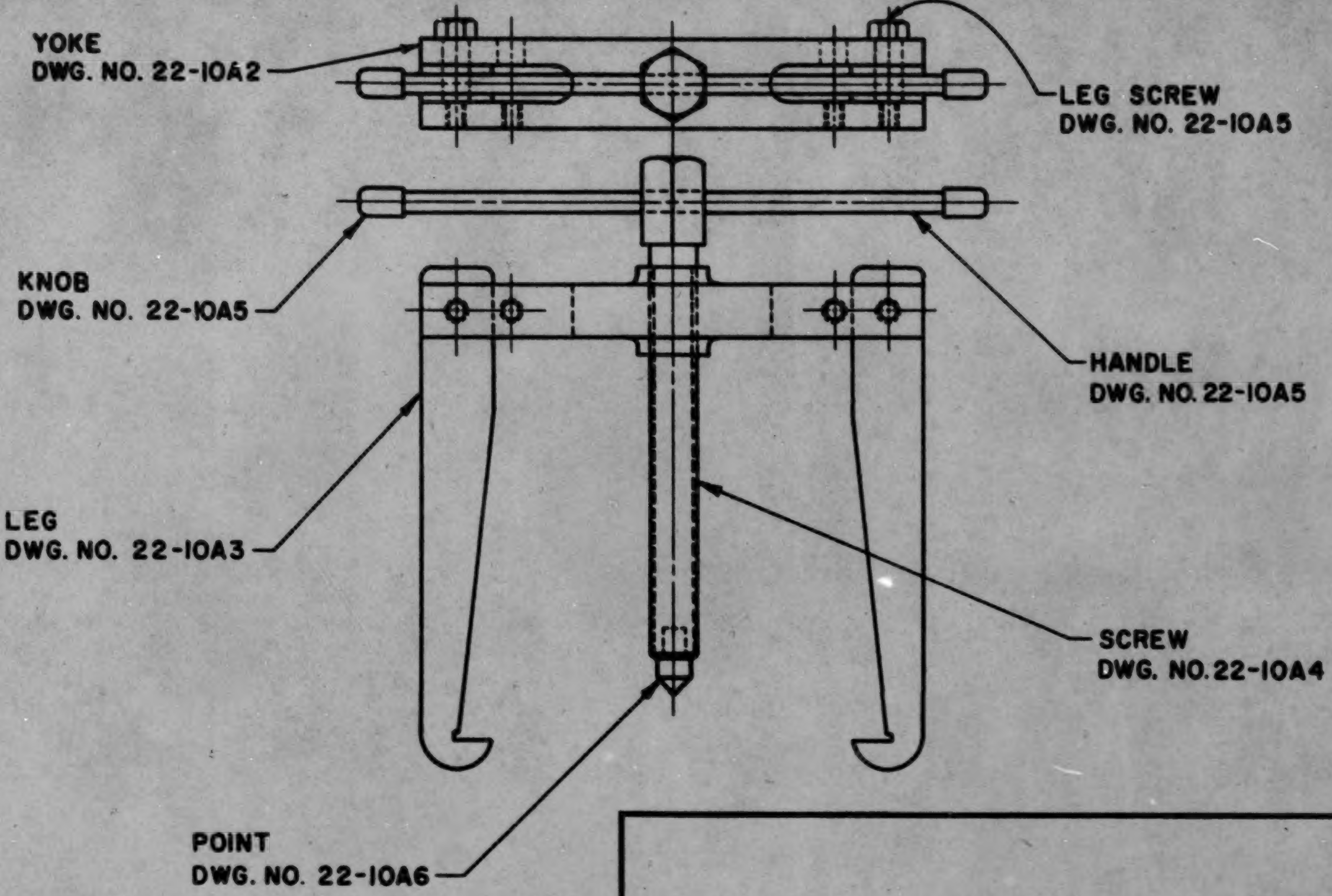
CENTER FINDER-SHANK

SHEET 3 OF 3

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2

DRAWING NUMBER
21-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY


YOKE
DWG. NO. 22-10A2
LEG SCREW
DWG. NO. 22-10A5
KNOB
DWG. NO. 22-10A5
HANDLE
DWG. NO. 22-10A5
LEG
DWG. NO. 22-10A3
SCREW
DWG. NO. 22-10A4
POINT
DWG. NO. 22-10A6

SCALE: 1" = 1"
DATE: 12-4-70
APPROVED BY:
DRAWN BY D. G. H.
REVISED

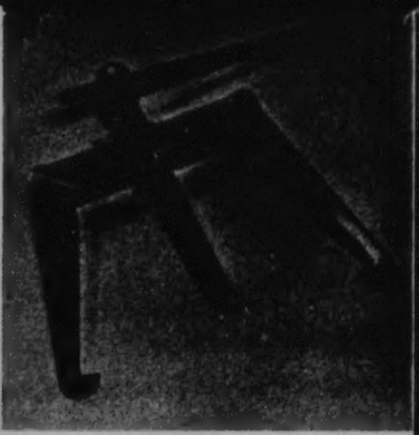
WHEEL PULLER-ASSEMBLY

SHEET 1 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2

DRAWING NUMBER
22-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY



JOB SHEET

Job No. J-22-10-50 Drawing No. 22-10A2

WHEEL PULLER - YOKE

EQUIPMENT: Lathe, vertical milling machine or shaper, and power cutoff saw.

TOOLS:
scriber
file card
layout dye
cutting oil
prick punch
3/8" reamer
11/32" drill
37/64" drill
center punch
layout hammer
12" steel rule
#3 drill (.213)
#4 center drill
0-1" micrometer
5/8"-18 N.F. tap
1/4"-28 N.F. tap
1/8" radius tool
1/8" radius gauge
10" mill file
left hand toolholder
adjustable tap wrench
right hand facing tool
Jacobs drill chuck to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

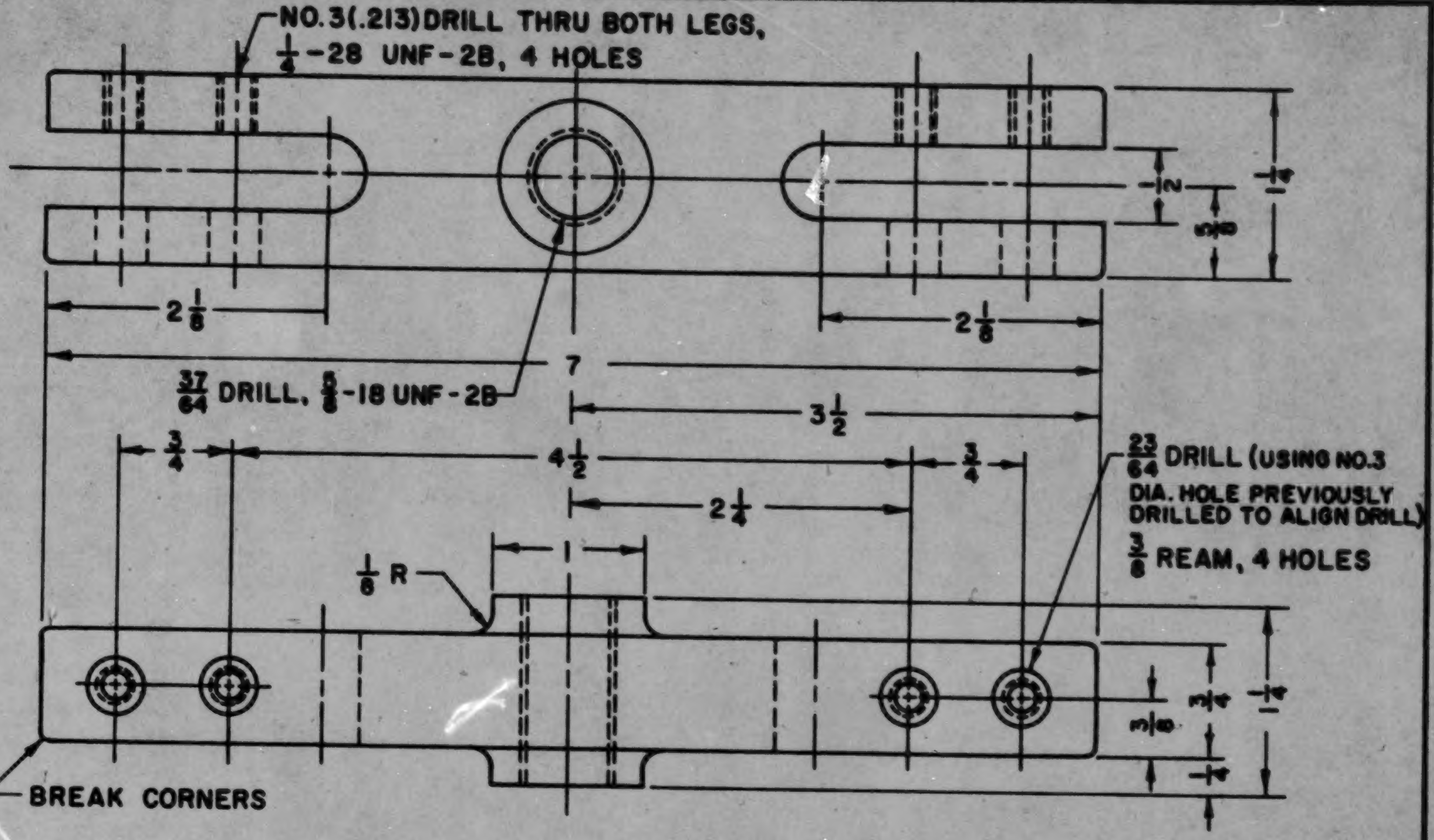
1. Use a piece of cloth when handling milling cutters.
2. Use a brush to remove accumulated chips, never bare hands or an air hose.
3. Make it a practice to know the location of the stop lever.

PROCEDURE:

1. Select the required material and cut to rough length.
2. Mount work piece on milling machine table.
3. Mill ends square and to length.
4. Mount work piece in 4 jaw chuck.
5. Face one side and turn boss as specified.
6. Turn 1/8" radius.
7. Center drill.
8. Drill 37/64" hole.
9. Reverse work piece in chuck centering the work piece with respect to the drilled hole.
10. Repeat steps 5 and 6.
11. Tap 5/8"-18 N.F. thread.
12. Layout work piece for slots and holes.
13. Mount work piece on milling machine to mill slots.
14. Mill slots (refer to Operation Sheet No. SL-4-5).
15. Drill and tap 1/4"-28 N.F. holes.

    NOTE: Finish all operations on each hole before proceeding to the next.

16. Drill and ream 3/8" holes.
17. Break all sharp edges.
18. Inspect as per print.



NO.3(.213) DRILL THRU BOTH LEGS,
1/4-28 UNF-2B, 4 HOLES
2 1/8
2 1/8
7
37/64 DRILL, 5/8-18 UNF-2B
3 1/2
3/4
4 1/2
3/4
2 1/4
1
1/8 R
23/64 DRILL (USING NO.3
DIA. HOLE PREVIOUSLY
DRILLED TO ALIGN DRILL)
3/8 REAM, 4 HOLES
1/2
5/8
1 1/4
3/4
3/8
1/4
1 1/4
BREAK CORNERS

MATERIAL – AISI – 1018 C.R.S.

SCALE: 1" = 1"
DATE: 11-25-70
APPROVED BY:
DRAWN BY D.G.H
REVISED

WHEEL PULLER-YOKE

SHEET 2 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER 22-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-22-10-51

Drawing No. 22-10A3

WHEEL PULLER - LEGS

EQUIPMENT: Vertical band saw or shaper, drill press, power cutoff saw, and surface grinder.

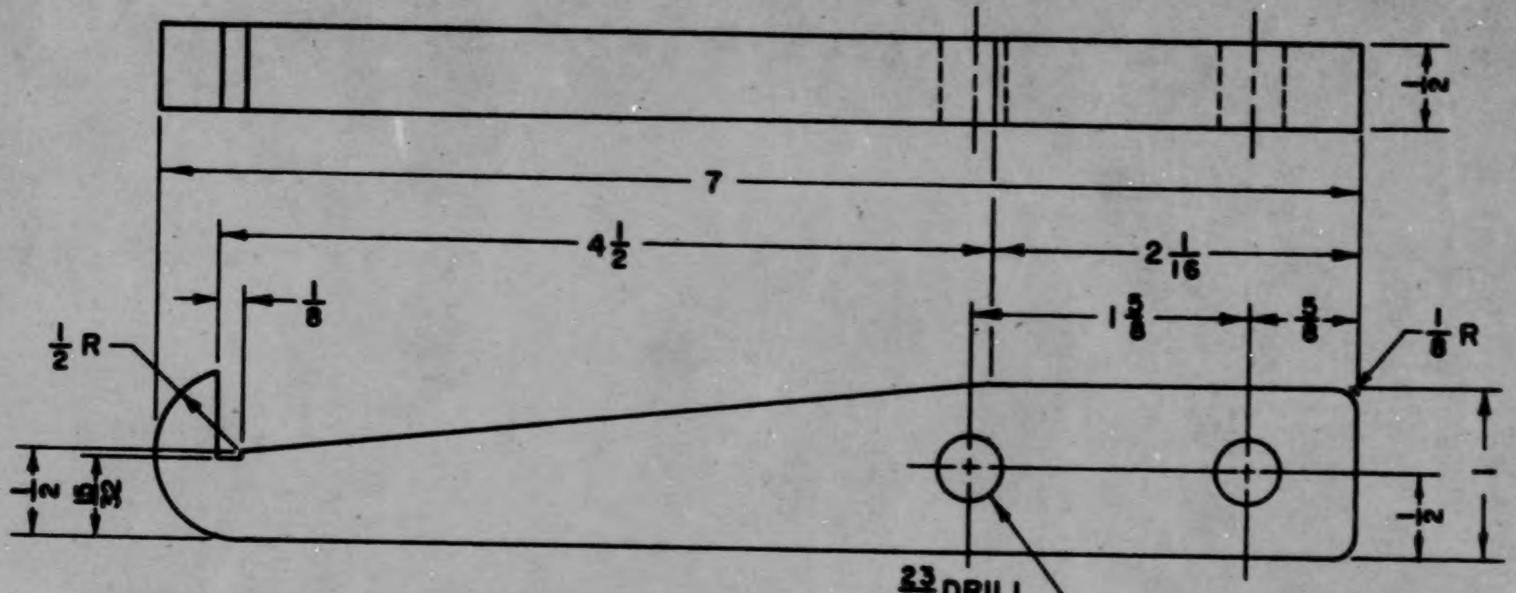
TOOLS:
scriber
file card
layout dye
prick punch
center punch
11/32" drill
layout hammer
6" steel rule
10" mill file
3/8" machine reamer

SAFETY PRECAUTIONS:

1. Handle band saw blades with extreme care. They are long and springy and can uncoil at high speeds causing serious cuts.

PROCEDURE:

1. Select required material and cut to length on power cutoff saw.
2. Layout work piece as per print.
3. Drill 11/32" holes.
4. Ream 3/8" holes.
5. Shape or saw work pieces to layout lines.
6. Grind and file radii on each leg.
7. Surface grind all plane surfaces.
8. Remove all burrs.
9. Inspect as per print.



$\frac{1}{2}$
7
$4\frac{1}{2}$
$2\frac{1}{16}$
$1\frac{5}{8}$
$\frac{5}{8}$
$\frac{1}{8}$ R
$\frac{1}{8}$
$\frac{1}{2}$ R
1
$\frac{1}{2}$
$\frac{1}{2}$
$\frac{15}{32}$

$\frac{23}{64}$ DRILL,
$\frac{3}{8}$ REAM,
2 HOLES

NOTE: 2 REQUIRED
MATERIAL - AISI - 1018 C.R.S.

SCALE: 1" = 1"
DATE: 11-25-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

WHEEL PULLER-LEG

SHEET 3 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ±1/64
DECIMAL DIMENSIONS ±.006
ANGULAR DIMENSIONS ±1 2

DRAWING NUMBER
22-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION–THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-22-10-52

Drawing No. 22-10A4

WHEEL PULLER - SCREW

EQUIPMENT: Lathe, drill press, and power cutoff saw.

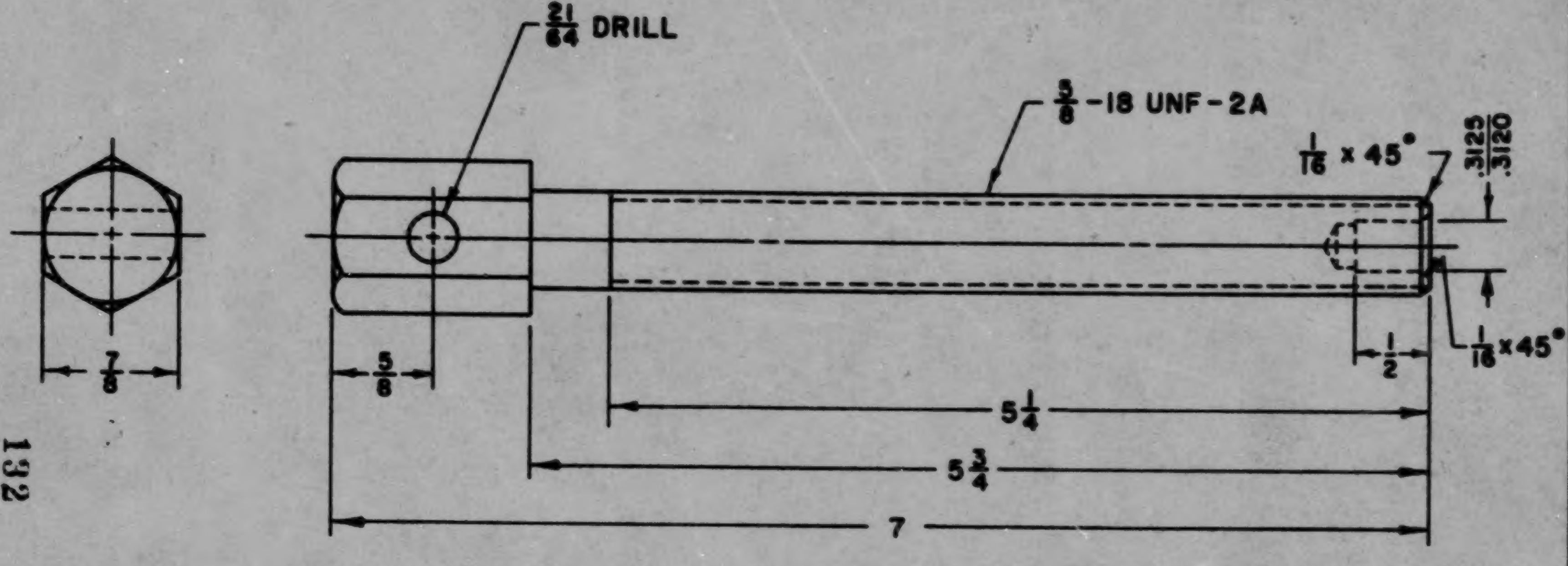
TOOLS:
- file card
- lathe dog
- layout dye
- 5/16" reamer
- 9/32" drill
- cutting oil
- center gauge
- screw-pitch gauge
- center punch
- layout hammer
- 12" steel rule
- abrasive cloth
- 0-1" micrometer
- #3 center drill
- lathe collet set
- 10" mill file
- 60° threading tool
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Keep hands and clothing free of revolving lathe dog.

PROCEDURE:

1. Saw required hex. material and cut to rough length on power cutoff saw.
2. Mount work piece in chuck.
3. Face and center drill one end.
4. Extend work piece 6" from jaws and support end with tailstock center.
5. Turn 5/8" thread diameter.
6. Chase 5/8"-18 N.F. thread as specified. Fit to yoke.
7. Mount screw in collet.
8. Drill 9/32" hole 5/8" deep.
9. Ream 5/16" hole 1/2" deep.
10. Form 1/16" x 45° internal and external chamfers.
11. Reverse work piece in collet.
12. Face to length.
13. File a slight radius on head.
14. Polish with abrasive cloth.
15. Layout 5/16" reamed hole.
16. Drill 9/32" hole in head.
17. Ream 5/16" hole.
18. Remove all burrs.
19. Inspect as per print.


21/64 DRILL
5/8-18 UNF-2A
1/16 x 45°
.3125/.3120
1/16 x 45°
1/2
7/8
5/8
5 1/4
5 3/4
7

MATERIAL - AISI - 1018 C.R.S. HEX. STOCK

SCALE: 1" = 1"
DATE: 11-26-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

WHEEL PULLER-SCREW

SHEET 4 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ±1/64
DECIMAL DIMENSIONS ±.005
ANGULAR DIMENSIONS ±1/2

DRAWING NUMBER
22-10A4

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-22-10-53

Drawing No. 22-10A5

WHEEL PULLER - KNOBS

EQUIPMENT: Lathe

TOOLS:
- file card
- cutting oil
- hand hacksaw
- 6" steel rule
- abrasive cloth
- #2 center drill
- #3 drill (.213)
- 1/4"-28 N.F. tap set
- adjustable tap wrench
- 6" mill file
- left hand toolholder
- right hand facing tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Use caution when filing close to chuck.

PROCEDURE:

1. Select sufficient material for two pieces.
2. Mount material in lathe collet.
3. Face and center drill.
4. Drill #3 hole to depth specified.
5. Tap 1/4"-28 N.F. thread.
6. Saw work piece to rough length with hand hacksaw.
7. Repeat steps 3 through 6 for second knob.
8. Reverse knob in collet.
9. Face knob to length.
10. File 1/16" radius.
11. Repeat steps 8 through 10 for second knob.
12. Polish both knobs with abrasive cloth.
13. Inspect as per print.

JOB SHEET

Job No. J-22-10-54

Drawing No. 22-10A5

WHEEL PULLER - HANDLE

EQUIPMENT: Lathe

TOOLS:
cutting oil
hand hacksaw
screw-pitch gauge
center gauge
12" steel rule
abrasive cloth
0-1" micrometer
60° threading tool
lathe collet set
1/16" necking tool
10" mill file
left hand toolholder
right hand facing tool
right hand turning tool

SAFETY PRECAUTIONS:

1. Do not extend small diameter stock from chuck or collet too far when turning or threading.

PROCEDURE:

1. Select required material and cut to rough length using hand hacksaw.
2. Mount work piece in collet and face.
3. Turn 1/4" thread diameter.
4. Form 1/16" undercut to 13/64" diameter.
5. Chase 1/4"-28 N.F. thread. Fit to knob.
6. Chamfer 30° to thread depth.
7. Reverse work piece in collet.
8. Face piece to length.
9. Repeat steps 3 through 6 for other end.
10. Remove all burrs.
11. Polish with abrasive cloth.
12. Inspect as per print.

JOB SHEET

Job No. J-22-10-55

Drawing No. 22-10A5

WHEEL PULLER - LEG SCREWS

EQUIPMENT: Lathe and power cutoff saw.

TOOLS:
- file card
- cutting oil
- screw-pitch gauge
- center gauge
- 6" steel rule
- 0-1" micrometer
- 60° threading tool
- 10" mill file
- left hand toolholder
- right hand facing tool
- right hand turning tool

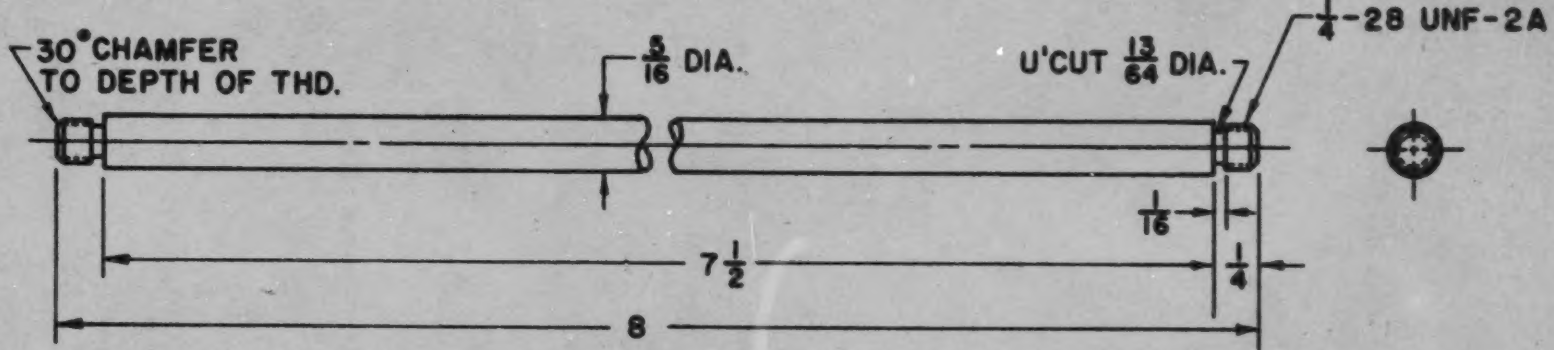
SAFETY PRECAUTIONS:

1. Be careful not to cut into lathe chuck with cutting tool.

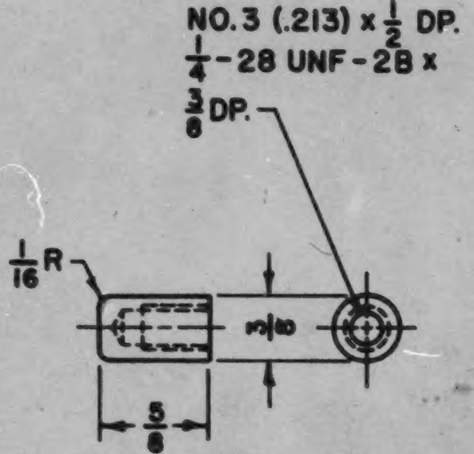
PROCEDURE:

1. Select required material and cut to rough length on power cutoff saw. Two pieces required.
2. Mount work piece in chuck and face.
3. Turn .375 diameter.
4. Turn 1/4" thread diameter.
5. Form 1/16" undercuts as specified.
6. Chase 1/4"-28 N.F. thread.
7. Chamfer 30° to thread depth.
8. Reverse work piece in chuck.
9. Face to length.
10. File chamfer on head.
11. Remove all burrs.
12. Inspect as per print.

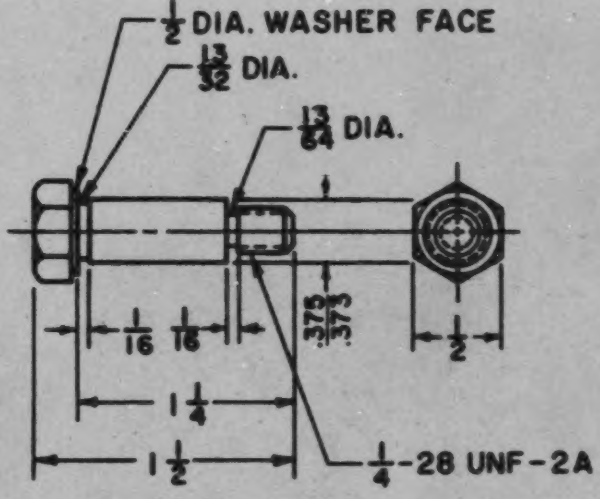
NOTE: All the above procedure will be the same for the second screw.


30° CHAMFER TO DEPTH OF THD.
5/16 DIA.
U'CUT 13/64 DIA.
1/4-28 UNF-2A
1/16
1/4
7 1/2
8

HANDLE


NO.3 (.213) x 1/2 DP.
1/4-28 UNF-2B x 3/8 DP.
1/16 R
3/8
5/8

KNOB


1/2 DIA. WASHER FACE
13/32 DIA.
13/64 DIA.
1/16
1/16
.375
.373
1/2
1 1/4
1 1/2
1/4-28 UNF-2A

LEG SCREW

MATERIAL - AISI-1018 C.R.S.

SCALE: 1"=1"	APPROVED BY:	DRAWN BY D.G.H.
DATE: 11-26-70		REVISED
WHEEL PULLER-DETAILS		
SHEET 5 OF 6	UNLESS OTHERWISE SPECIFIED: FRACTIONAL DIMENSIONS ±1/64 DECIMAL DIMENSIONS ±.005 ANGULAR DIMENSIONS ±1/2	DRAWING NUMBER 22-10A5

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-22-10-56

Drawing No. 22-10A6

WHEEL PULLER - POINT

EQUIPMENT: Lathe, heat treating furnace, and power cutoff saw.

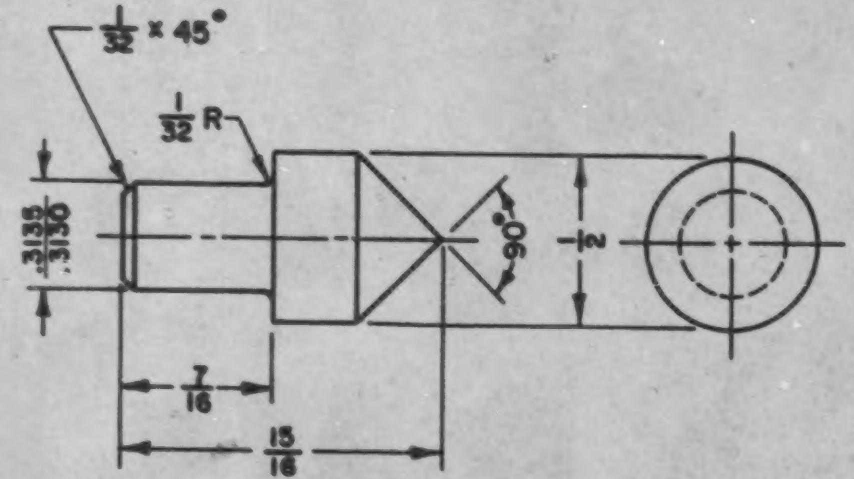
TOOLS:
- file card
- cutting oil
- 6" steel rule
- abrasive cloth
- 0-1" micrometer
- lathe collet set
- 10" mill file
- left hand toolholder
- right hand facing tool
- right hand turning tool

SAFETY PRECAUTIONS:

1. Never stand in front of a heat treating furnace when it is being ignited.
2. Work only in areas that are well ventilated.

PROCEDURE:

1. Select the required material and cut to length on power cutoff saw.
2. Mount work piece in collet.
3. Face one end.
4. Turn .3135 diameter to length.
5. Turn 1/32" x 45° chamfer.
6. Reverse work piece in collet and face to length.
7. Adjust compound rest to turn 90° point.
8. Turn 90° point.
9. Polish with abrasive cloth.
10. Harden and temper.
11. Repolish with abrasive cloth.
12. Assemble point to screw.
13. Inspect as per print.



MATERIAL - AISI-1018 C.R.S.

SCALE: 2" = 1"
DATE: 11-26-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

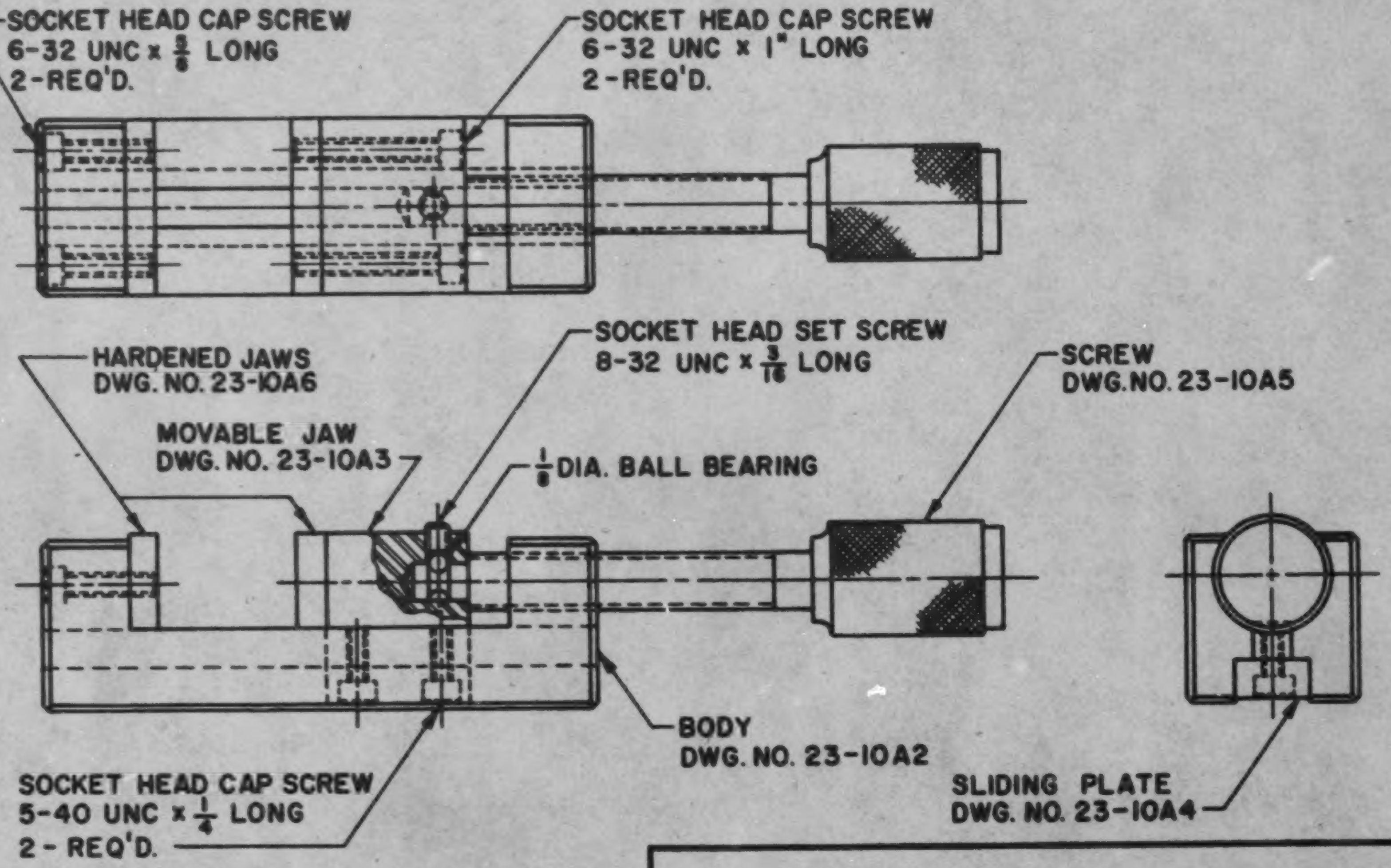
WHEEL PULLER-POINT

SHEET 6 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
22-10A6

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY


SOCKET HEAD CAP SCREW
6-32 UNC x 3/8 LONG
2-REQ'D.
SOCKET HEAD CAP SCREW
6-32 UNC x 1" LONG
2-REQ'D.
HARDENED JAWS
DWG. NO. 23-10A6
MOVABLE JAW
DWG. NO. 23-10A3
SOCKET HEAD SET SCREW
8-32 UNC x 3/16 LONG
1/8 DIA. BALL BEARING
SCREW
DWG. NO. 23-10A5
BODY
DWG. NO. 23-10A2
SOCKET HEAD CAP SCREW
5-40 UNC x 1/4 LONG
2 - REQ'D.
SLIDING PLATE
DWG. NO. 23-10A4

SCALE: 1" = 1"
DATE: 12-10-70
APPROVED BY:
DRAWN BY: D. G. H.
REVISED

TOOLMAKER'S VISE - ASSEMBLY

SHEET 1 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
23-10A1

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-23-10-57 Drawing No. 23-10A2

TOOLMAKERS VISE - BODY

EQUIPMENT: Vertical milling machine or horizontal milling machine, surface grinder, and power cutoff saw.

TOOLS:
- scriber
- file card
- layout dye
- cutting oil
- 5/16" drill
- 11/64" drill
- 6" steel rule
- layout hammer
- surface gauge
- 0-1" micrometer
- 10" mill file
- 17/64" counterbore
- 3/8"-16 N.C. tap set
- 0-6" vernier, caliper
- depth micrometer

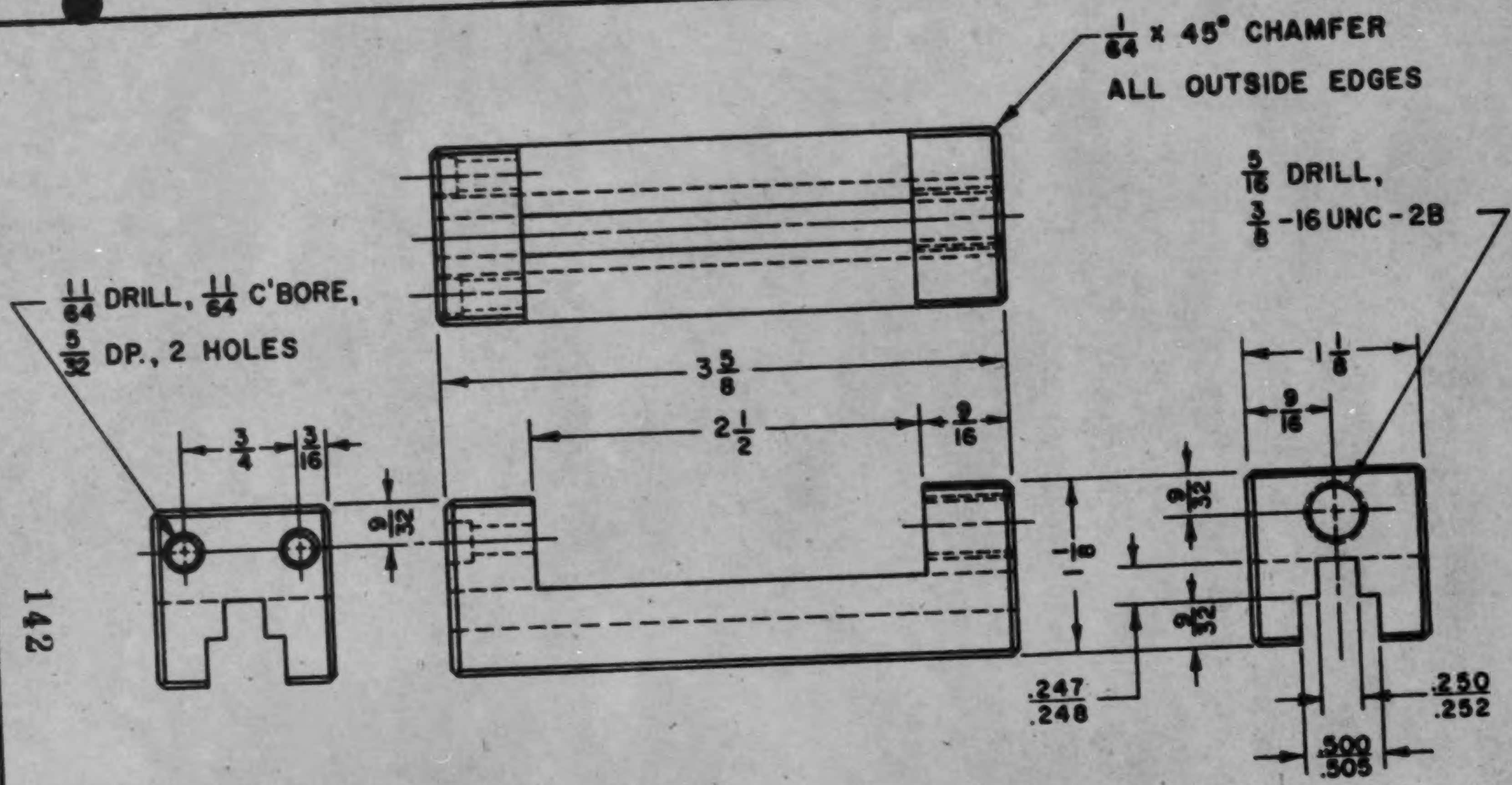
SAFETY PRECAUTIONS:

1. Use brush for cleaning away chips.
2. Keep hands and tools away from revolving cutter.
3. Check grinding wheel for cracks.
4. Keep hands away from revolving grinding wheels.

PROCEDURE:

1. Select required material and cut to rough length on power cutoff saw.
2. Mount work piece on milling machine.
3. Mill ends to length and remove burrs.
4. Layout vise cavity.
5. Remount work piece on milling machine.
6. Mill cavity allowing approximately .010" for grinding.
7. Mount work piece on surface grinder.
8. Square top, bottom, and sides by surface grinding.
9. Clamp to angle plate and grind both ends square.
10. Layout 1/4" and 1/2" grooves and hole locations.
11. Remount work piece on milling machine.
12. Mill grooves.
13. File 1/32" x 45° angle along cavity side of groove.
14. Remount work piece on milling machine.
15. Surface grind faces for fixed jaws and rails between jaws.
16. Clamp work piece to angle plate on milling machine.
17. Drill 11/64" holes.

18. Counterbore 11/64" holes to 17/64" as specified.
19. Drill 5/16" hole.
20. Tap 3/8"-16 N.C. hole.
21. Chamfer 1/16" x 45° all outside edges.
22. Remove all burrs.
23. Inspect as per print.


$\frac{1}{64}$ x 45° CHAMFER
ALL OUTSIDE EDGES
$\frac{5}{16}$ DRILL,
$\frac{3}{8}$-16 UNC-2B
$\frac{11}{64}$ DRILL, $\frac{11}{64}$ C'BORE,
$\frac{5}{32}$ DP., 2 HOLES
$3\frac{5}{8}$
$2\frac{1}{2}$
$\frac{9}{16}$
$\frac{3}{4}$
$\frac{3}{16}$
$\frac{9}{32}$
$1\frac{1}{8}$
$\frac{9}{16}$
$\frac{9}{32}$
$1\frac{1}{8}$
$\frac{9}{32}$
$\frac{.247}{.248}$
$\frac{.250}{.252}$
$\frac{.500}{.505}$

MATERIAL - AISI - 1018 C.R.S.

SCALE: 1" = 1"
DATE: 12-10-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

TOOLMAKER'S VISE - BODY

SHEET 2 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
23-10A2

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-23-10-58

Drawing No. 23-10A3

TOOLMAKERS VISE - MOVABLE JAW

EQUIPMENT: Vertical milling machine, surface grinder, and metal cutting band saw.

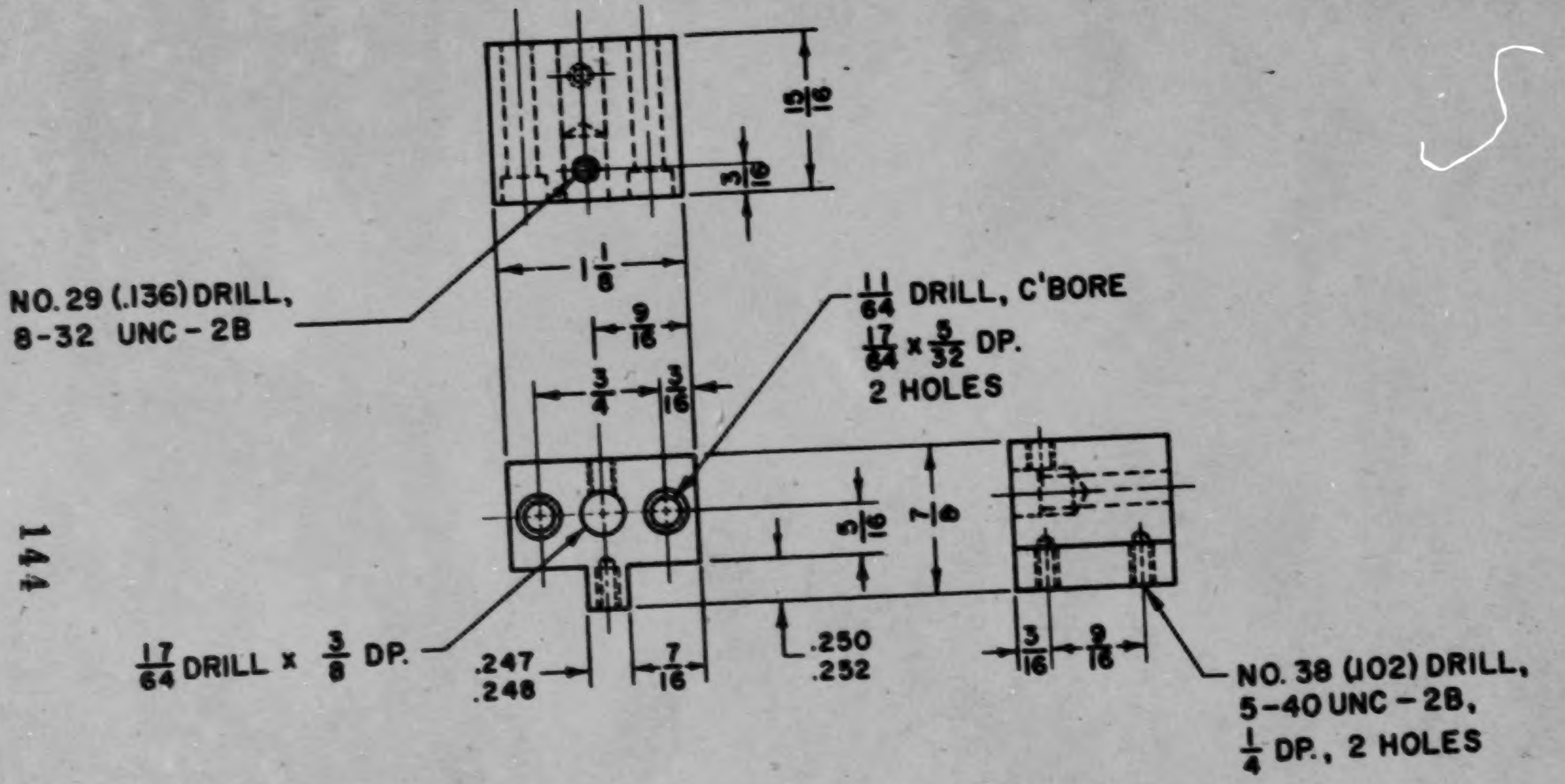
TOOLS:
- scriber
- file card
- layout dye
- 1/4" drill
- cutting oil
- 11/64" drill
- 10" mill file
- 17/64" drill
- surface gauge
- layout hammer
- 6" steel rule
- 0-1" micrometer
- #2 center drill
- #29 drill (.1405)
- #38 drill (.1015)
- 5-40 N.C. tap set
- 8-32 N.C. tap set
- 17/64" counterbore
- adjustable tap wrench

SAFETY PRECAUTIONS:

1. Block part well on magnetic chuck.
2. Remove work from table before checking.

PROCEDURE:

1. Select required material and cut to rough length on band saw.
2. Mount work piece on milling machine.
3. Mill ends square allowing .005" at each end for finish.
4. Mount work piece on surface grinder.
5. Grind block square.
6. Layout offset on bottom of jaw.
7. Remount work piece on milling machine.
8. Mill offset allowing .005" on all surfaces for grinding.
9. Layout hole locations.
10. Drill #38 holes.
11. Tap 5-40 N.C. holes.
12. Drill 17/64" hole.
13. Drill 11/64" holes.
14. Counterbore 11/64" holes to 17/64" as specified.
15. Drill #29 hole through 17/64" hole.
16. Tap 8-32 N.C. hole.
17. Remount work piece on surface grinder.
18. Grind 1/4" width to allow .001" clearance with mating part.
19. Grind 1/4" length to allow .001" clearance with sliding part.
20. Remove all burrs.
21. Inspect as per print.



15/16
3/16
1 1/8
NO. 29 (.136) DRILL,
8-32 UNC - 2B
9/16
11/64 DRILL, C'BORE
17/64 x 5/32 DP.
2 HOLES
3/4
3/16
5/16
7/8
17/64 DRILL x 3/8 DP.
.247
.248
7/16
.250
.252
3/16
9/16
NO. 38 (.102) DRILL,
5-40 UNC - 2B,
1/4 DP., 2 HOLES

MATERIAL - AISI - 1018 C.R.S.

SCALE: 1" = 1"
DATE: 12-7-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

TOOLMAKER'S VISE - MOVABLE JAW

SHEET 3 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1/2

DRAWING NUMBER
23-10A3

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-23-10-59 Drawing No. 23-10A4

TOOLMAKERS VISE - SLIDING PLATE

EQUIPMENT: Vertical milling machine, surface grinder, and power cutoff saw.

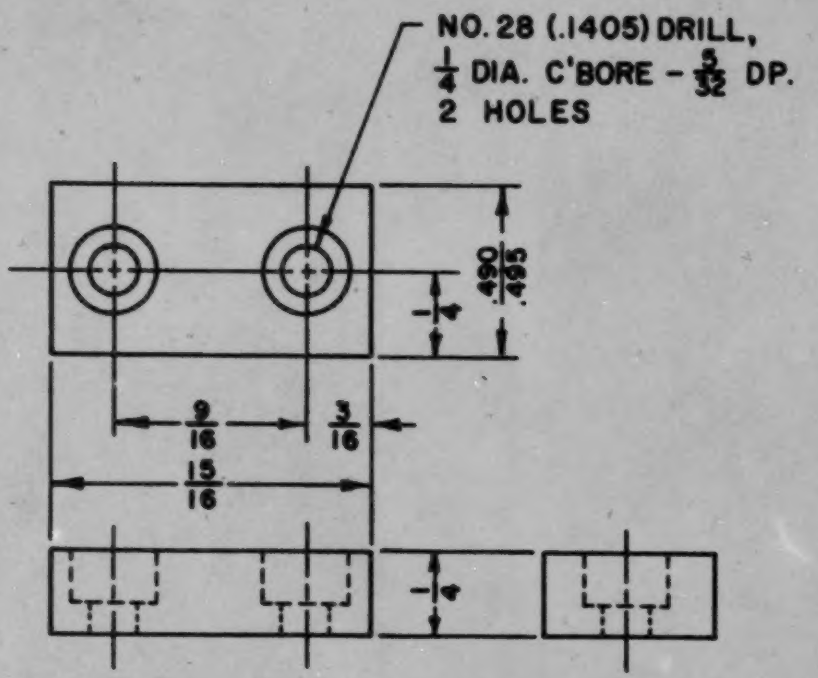
TOOLS:
- scriber
- file card
- layout dye
- 1/4" drill
- prick punch
- center punch
- 6" steel rule
- center finder
- layout hammer
- 0-1" micrometer
- #2 center drill
- 1/4" counterbore
- #28 drill (.1405)
- 10" mill file

SAFETY PRECAUTIONS:

1. Wheel guards should always cover at least one-half of the grinding wheel.
2. Always make a visual check of the grinding wheel before starting the machine.

PROCEDURE:

1. Select required material and cut to rough length on power cutoff saw.
2. Mount work piece on milling machine.
3. Mill ends square and to length.
4. Layout hole location.
5. Center drill for holes.
6. Drill #28 holes.
7. Counterbore #28 holes to 1/4" as specified.
8. Mount work piece on surface grinder.
9. Grind all surfaces.
10. Grind edges square to fit 1/2" groove, allowing .001" clearance for movement.
11. Remove all burrs.
12. Inspect as per print.


NO. 28 (.1405) DRILL,
1/4 DIA. C'BORE - 5/32 DP.
2 HOLES
.490/.495
1/4
9/16
3/16
15/16
1/4

MATERIAL - AISI - 1018 C.R.S.

SCALE: 2" = 1" DATE: 12-5-70	APPROVED BY:	DRAWN BY D.G.H. REVISED

TOOLMAKER'S VISE - SLIDING PLATE

SHEET 4 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ±1 2

DRAWING NUMBER
23-10A4

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-23-10-60

Drawing No. 23-10A5

TOOLMAKERS VISE - SCREW

EQUIPMENT: Lathe and power cutoff saw.

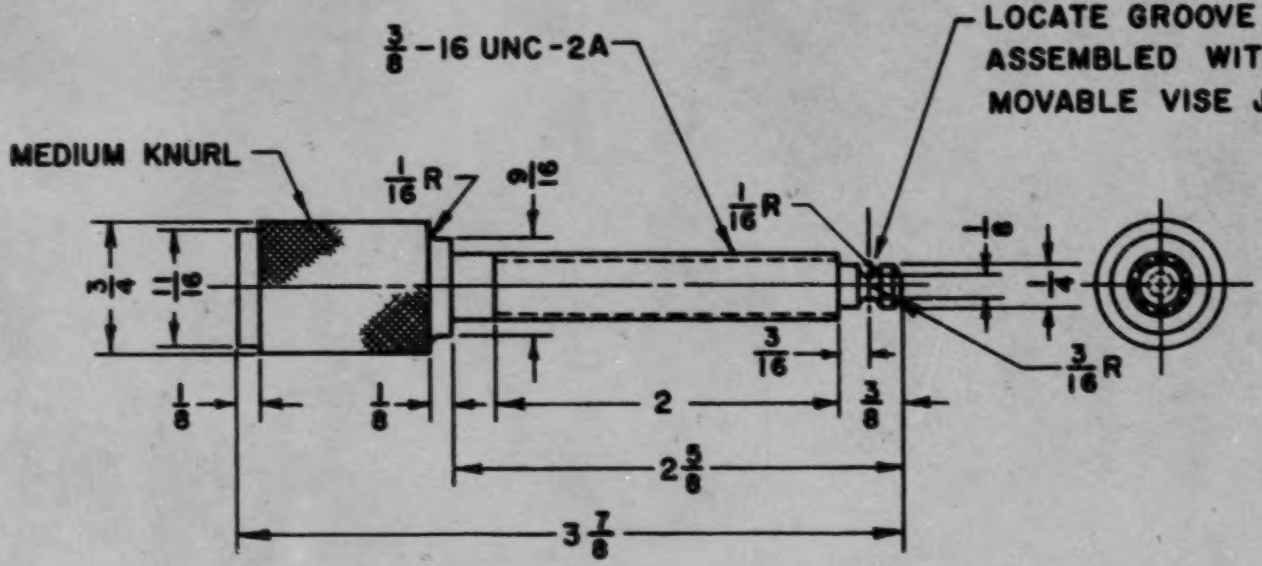
TOOLS:
- scriber
- file card
- layout dye
- cutting oil
- screw-pitch gauge
- center gauge
- 6" steel rule
- knurling tool
- #2 center drill
- lathe collet set
- 1/16" radius tool
- 60° threading tool
- 10" mill file
- left hand toolholder
- right hand facing tool
- right hand turning tool
- Jacobs drill chuck with Morse taper to fit lathe tailstock spindle

SAFETY PRECAUTIONS:

1. Be sure knurling tool is clamped short.
2. Do not clean knurled areas with a rag or brush while the lathe spindle is revolving.

PROCEDURE:

1. Select required material and cut to rough length on power cutoff saw.
2. Mount work piece in collet and face one end.
3. Knurl section as per print.
4. Turn 11/16" diameter.
5. Reverse work piece in collet.
6. Face and center drill end.
7. Extend work piece 3" and support with tailstock center.
8. Turn 3/8" thread diameter.
9. Turn 1/4" diameter.
10. Chase 3/8"-16 N.C. thread. Use vise body to check fit.
11. Layout location of ball groove on 1/4" diameter by inserting into hole in jaw and marking the groove through the 8-32 N.C. tapped hole.
12. Form 1/16" groove and shoulder radius.
13. Remove center hole by facing.
14. File radius on end of screw.
15. Remove all burrs.
16. Inspect as per print.


$\frac{3}{8}$-16 UNC-2A
LOCATE GROOVE WHEN ASSEMBLED WITH MOVABLE VISE JAW
MEDIUM KNURL
$\frac{1}{16}$R
$\frac{9}{16}$
$\frac{1}{16}$R
$\frac{1}{8}$
$\frac{1}{4}$
$\frac{3}{4}$
$\frac{11}{16}$
$\frac{3}{16}$
$\frac{3}{16}$R
$\frac{1}{8}$
$\frac{1}{8}$
2
$\frac{3}{8}$
$2\frac{5}{8}$
$3\frac{7}{8}$

MATERIAL - AISI-1018 C.R.S.

SCALE: 1" = 1"
DATE: 12-7-70
APPROVED BY:
DRAWN BY D. G. H.
REVISED

TOOLMAKER'S VISE - SCREW

SHEET 5 OF 6
UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ± 1/64
DECIMAL DIMENSIONS ± .005
ANGULAR DIMENSIONS ± 1 2
DRAWING NUMBER
23-10A5

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

JOB SHEET

Job No. J-23-10-61

Drawing No. 23-10A6

TOOLMAKERS VISE - HARDENED JAWS

EQUIPMENT: Vertical milling machine, surface grinder, heat treating furnace, and power cutoff saw.

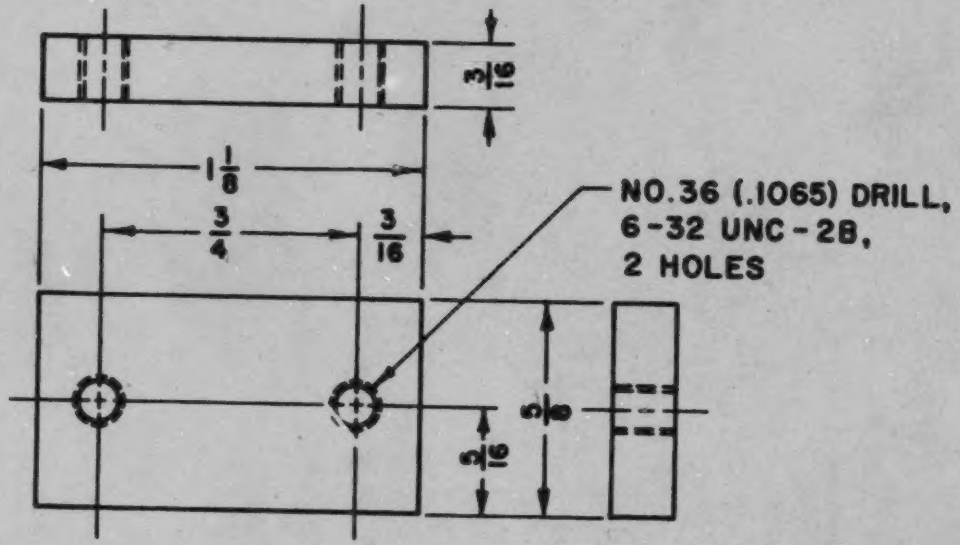
TOOLS:
- tongs
- scriber
- file card
- layout dye
- prick punch
- center punch
- 6" steel rule
- layout hammer
- asbestos gloves
- 6-32 N.C. tap
- #2 center drill
- #36 drill (.1065)
- 10" mill file
- adjustable tap wrench

SAFETY PRECAUTIONS:

1. Always use tongs when loading or unloading a furnace.
2. Be careful to use the correct wheel for the material being ground.

PROCEDURE:

1. Select required material and cut two pieces to rough length on the power cutoff saw.
2. Mount work pieces on milling machine.
3. Square ends to length.
4. Layout hole locations.
5. Drill #36 hole.
6. Tap 6-32 N.C. holes.
7. Harden and temper jaws.
8. Mount work piece on surface grinder.
9. Grind all flat surfaces.
10. Inspect as per print.


3/16
1 1/8
3/4
3/16
5/8
5/16
NO.36 (.1065) DRILL,
6-32 UNC-2B,
2 HOLES

NOTE: 2 REQUIRED
MATERIAL -AISI-C1090 FLAT GRND. TL. STL.
HEAT TREATMENT - HARDEN AND TEMPER

SCALE: 2" = 1"
DATE: 12-5-70
APPROVED BY:
DRAWN BY D.G.H.
REVISED

TOOLMAKER'S VISE - HARDENED JAWS

SHEET 6 OF 6

UNLESS OTHERWISE SPECIFIED:
FRACTIONAL DIMENSIONS ±1/64
DECIMAL DIMENSIONS ±.005
ANGULAR DIMENSIONS ±1/2

DRAWING NUMBER
23-10A6

PREPARED BY THE DEPARTMENT OF VOCATIONAL EDUCATION—THE PENNSYLVANIA STATE UNIVERSITY

Section 7

OPERATION SHEETS

Operation Sheets supplement the job sheets and indicate to the student how to perform the operations (skills) necessary to complete the assigned jobs. The skills (operations) that will be taught in this course are listed in Section 5B. The operation sheets included in this section (Section 7) are numbered to correspond with the skill demonstration lessons listed in the COURSE OUTLINE (Section 5).

OPERATION SHEET

Operation Sheet No. SL-1-1

HOW TO:	Drill Center Holes
COURSE OF STUDY:	Machine Shop Practice - Lathe Operation
INTRODUCTION:	Center drilling is the process of drilling and countersinking a hole with a cone-shaped opening to provide a bearing for the lathe centers on which work revolves.
TOOLS AND EQUIPMENT:	Engine lathe, combination drill and countersink.

PROCEDURE:

1. Select a lathe chuck of the size and type suited to the job.

2. Mount chuck on lathe spindle (refer to Operation Sheet No. SL-1-25).

3. Face end of work square (refer to Operation Sheet No. SL-1-17).

4. Select a combination drill and countersink of suitable size (refer to Information Sheet No. IL-1-8).

5. Mount drill chuck in tailstock spindle and grip center drill in chuck.

6. Slide tailstock forward until the point of the drill nearly touches the work, then clamp tailstock in position.

7. Increase spindle speed to accommodate size of drill. R.P.M. should always be higher than turning speed.

8. Start the lathe.

9. Turn the tailstock handwheel to feed the center drill to the work.

   NOTE: Bring the drill up to the face of the revolving work and note whether drill point is in line with center of work piece. If out of alignment, adjust tailstock to permit the drill to center properly and prevent drill breakage.

10. Apply a few drops of cutting oil to the point of the drill and feed slowly to the required depth.

OPERATION SHEET

Operation Sheet No. SL-1-2

HOW TO: Mount Work Between Centers

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Work that is to be turned accurately and concentrically between lathe centers must be mounted correctly in order to provide a good bearing and support for the center holes of the job.

Some of the important factors to be considered in the mounting of a job between centers are: the alignment of lathe centers, the trueness of the live center, the condition of the center holes, the lubrication of the tailstock center, the adjustment of the work between centers and the adjustment of the lathe dog in regard to the work and driver plate.

TOOLS AND EQUIPMENT: Engine lathe, lathe centers, lathe dog and wrench, and lead hammer.

PROCEDURE:

1. Select the lathe dog suited to the job at hand.
2. Attach the lathe dog to the work with the bent tail pointing away from the job and in position to be driven by the driver plate.

   NOTE: Finished surfaces should be protected with a piece of soft brass or copper so that, when tightened, the set screw will not mar the work.

3. Clean the tapered holes in the headstock and tailstock spindles.

   CAUTION: Stop the lathe when wiping the spindle hole. The fingers should never be put into a revolving spindle to remove dirt. A safe and effective way of wiping the spindle bore is to use a piece of cloth wound around a stick.

4. Examine the lathe centers and spindle sleeve to make sure they are free of burrs. Remove burrs or raised ends with a file or oilstone wipe surfaces clean.
5. Fit the dead center to the hole in the tailstock spindle.

6. Insert the live center in the spindle sleeve, mount in headstock spindle, and then tap into position with a lead mallet.

7. Rotate the lathe spindle, by power, to check the trueness of the live center. If center runs out, remove it from the spindle by jarring it loose with a knockout bar. Recheck for dirt or burrs and reassemble.

8. Check approximate alignment of lathe centers by sliding the tailstock forward until the two centers are nearly touching, correct any error in alignment by adjusting set-over screws.

9. Clean the threads of spindle nose and driver plate.

10. Apply a few drops of oil to the threads and mount the driver plate on the spindle.

11. Clean the ways of the lathe, move the tailstock into approximate position to accommodate the length of work and clamp.

12. Clean the center holes of the work. Apply a few drops of white lead and oil mixture to the tailstock center hole.

13. Hold the work in the left hand and place the countersunk hole on the headstock center so that the tail of the dog is freely engaged in a slot on the driver plate. In case the tail of the dog does not enter the slot freely, loosen the set screw and adjust the dog so that the tail does not bind against the sides of the slot.

14. Move the center toward the work by turning the tailstock handwheel. When the job is supported on the centers, adjust the dead center so that no play can be felt between the work and the centers. At the same time, the work should be free enough so that the weight of the dog is sufficient to cause it to drop when moved to one side of the slot.

OPERATION SHEET

Operation Sheet No. SL-1-3

HOW TO:	Face Work Mounted Between Centers on a Lathe
COURSE OF STUDY:	Machine Shop Practice - Lathe Operation
INTRODUCTION:	Facing or "squaring" on the lathe is the process of machining ends of work flat, smooth, at right angles to the axis of the job, and to the required length.
TOOLS AND EQUIPMENT:	Engine lathe, half center, lathe dog, and steel rule.

PROCEDURE:

1. Mount the work between centers, using a half center in the tailstock.

   NOTE: The adjustment of the tailstock center is an important consideration in facing. When the tailstock center is out of line toward the operator, a concave end is formed. If the tailstock center is out of line away from the operator, a convex end will result.

2. Select a facing tool of kind and shape desired and mount it in toolholder with the point of the tool on level with the point of the tailstock center.
3. Adjust the compound rest to 30°.
4. Set the cutting edge of the tool against the end of the work at an angle slightly more than 90° to permit the point to do most of the cutting.
5. Start the lathe.
6. Move the carriage and cross slide to bring the point of the tool in contact with the end of the work.
7. Lock the carriage in position by tightening the carriage lock.
8. Back the cross slide out so that the tool clears the work.
9. Feed the tool into the work by turning the crossfeed handle to rough face end.

NOTE: The proper amount of material can be removed by feeding the compound rest in twice the amount to be removed.

10. Finish face end by starting tool at center and facing outward. A light cut is taken by feeding the tool into the work a slight amount with the compound rest.

11. Start the cut by hand with the crossfeed handle and then engage the power feed.

12. Mount the work end for end on the lathe centers and repeat the facing operation on the opposite end.

OPERATION SHEET

Operation Sheet No. SL-1-4

HOW TO: Straight Turn Between Centers

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Straight or cylindrical turning, on the lathe, is the process of machining a revolving piece of work by feeding a cutting tool longitudinally along the piece, in order to produce sides that are parallel to the axis of the work.

TOOLS AND EQUIPMENT: Engine lathe, outside calipers, micrometer calipers, and steel rule.

PROCEDURE:

1. Align lathe centers (refer to Operation Sheet No. SL-1-5).
2. Mount work between centers (refer to Operation Sheet No. SL-1-2).
3. Set the outside calipers to required diameter.
4. Place a right-hand turning tool in the toolholder.

   NOTE: Make sure that the tool is ground to proper shape, rake and clearance (refer to Operation Sheet No. SL-1-26). Adjust the toolholder in the tool post so that the cutting tool is inclined slightly toward the tailstock to prevent digging into the work when taking heavy cuts.
5. Set the cutting edge of the tool at the height of center.
6. Move the carriage along the ways to make sure that the tool can travel to the desired length without interference.
7. Engage headstock gears or shift belt to obtain correct speed for material to be turned (refer to Operation Sheet No. SL-1-24).
8. Start the lathe and feed the tool in until it touches the revolving work. Move the carriage to the right so that the tool clears the end of the work piece.
9. Set the graduated collar at "zero" and then turn the cross slide handle to move the tool in to the desired depth of cut by taking the reading on the graduated collar (refer to Information Sheet No. IL-1-18).

NOTE: Lost motion or "backlash" in the cross slide and compound rests can be overcome by turning the feed screw in toward the work for each cut.

10. Move the carriage, by hand, and take a cut of 1/16" or 1/8" from the end to permit measuring the diameter.

11. Stop the lathe and measure the work, for size, with the calipers.

CAUTION: Calipers should never be used on revolving work. Always stop the lathe when taking measurements.

12. Make the necessary adjustments for the depth of cut.

13. Engage the longitudinal feed clutch and start the cut.

CAUTION: Under no circumstances are chips to be removed by hand. In order to prevent personal injury, use a hook pliers or a piece of wood to remove chips.

14. Rough turn the job to the desired length.

15. Disengage the feed and stop the lathe.

CAUTION: The frictional heat, which develops as the piece is being turned, causes the work to expand and tighten on the lathe centers. If the centers develop a squeak, disengage the feed, stop the lathe, loosen the tail center, and apply white lead and oil. Readjust the work on centers.

16. Caliper both ends of the job to determine whether the work is parallel.

NOTE: If the work is not turned parallel, make necessary adjustment on the tailstock to align the lathe centers.

17. Insert a keen edge finish turning tool in the tool holder. Set point on center and clamp securely.

18. Decrease the amount of feed and increase the spindle speed for finish turning (refer to Operation Sheets No. SL-1-23 and 24).

19. Return the carriage to the starting position (tailstock end of work piece), bring the point of the tool in contact with the revolving work.

20. Reset the graduated collar on the cross slide, to zero and move the tool in to take a light cut.

21. Take a trial cut for a short distance and measure the diameter with the micrometer caliper.

22. Make the necessary adjustments, in depth, to get the piece down to finish size by taking short trial cuts on the end of the piece.

23. Finish turn the job to the required diameter.

24. Return all tools to proper place.

25. Clean machine.

OPERATION SHEET

Operation Sheet No. SL-1-5

HOW TO: Align Lathe Centers

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: The tailstock of the lathe is constructed so as to provide a transverse movement of the tailstock body on its base plate at right angles to the ways of the lathe. The body can be moved in either direction by adjusting screws. The amount of movement may be measured on a scale at the back or front ends of the tailstock.

The lathe centers must be in exact alignment to turn a true cylinder. When the centers are in alignment, the axis of the live center coincides with that of the dead center.

The method of checking the accuracy of alignment depends largely on the nature of the work. The approximate method of aligning lathe centers is satisfactory for work to be rough turned or where great accuracy is not required. The centers may be checked for approximate alignment by either bringing the live and dead centers together, or by adjusting the "witness marks" on the tailstock until the "zero" lines coincide.

TOOLS AND EQUIPMENT: Engine lathe, open end wrench and/or screw driver.

PROCEDURE:

1. Mount live center in headstock spindle and check for trueness.
2. Wipe the ways of the lathe clean.
3. Slide the tailstock along the ways until the live and dead center are within a short distance of each other.
4. Clamp tailstock to lathe bed, turn the handwheel to bring the tail center close to the point of the head stock center, and clamp the spindle.
5. Look down over the centers and note the alignment of the center points. If the tail center is out of line, make the necessary adjustment by turning the set-over or adjusting screws.

NOTE: In order to move the tailstock body on its base plate, it is necessary to loosen the clamping bolt, to permit adjustment by the set-over screws.

Lathe centers may also be checked for approximate alignment by adjusting the tailstock body on its base until the "zero" line of the witness marks coincide.

OPERATION SHEET

Operation Sheet No. SL-1-6

HOW TO: Turn Shoulders

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Shoulder turning is the process of machining the surface between two different diameters to a definite shape. There are three general types of shoulders: the square corner, which is usually turned with either the right or left-hand facing tool or a side tool; the filleted corner, which may be turned with a round nose turning tool or radius tool; and the beveled or angular shoulder, which may be formed with the chamfering tool, the square nose tool, or the side of a turning tool.

TOOLS AND EQUIPMENT: Hermaphrodite caliper, engine lathe, tool bits for shoulder turning, toolholder, scriber, steel rule, and chalk or layout dye.

PROCEDURE:

A. Procedure Common to All Shoulders

1. Lay off the location of the shoulder from the faced end of the work.

2. Set up lathe for turning.

3. Turn the diameter of the work to within 1/64" of the finished size and allow sufficient material at the shoulder to permit turning to the desired shape.

B. How to Turn Square Shoulders

1. Finish turn the diameter to the required size and leave enough material at the shoulder for facing.

2. Set up lathe with facing tool.

3. Rough turn the remaining material at corner of shoulder.

   NOTE: Where a considerable amount of material is to be removed, it may be "stepped off."

4. Move the point of the tool in toward the finished diameter so that it barely touches the surface, then set the graduated collar on the cross slide at "zero."

5. Back the tool away from the work.

6. Move the point of the tool against the shoulder of the rotating work and take a light cut by feeding inward to the "zero" setting on the graduated collar. Face the shoulder to split the scribed line.

   NOTE: The distance to the shoulders may be laid off by use of the hermaphrodite caliper or the steel rule and scriber. The work may be coated with chalk or layout dye to make the scribed lines more visible.

7. Feed the tool inward again slightly beyond the "zero" setting of the graduated collar. Then move the tool away from the shoulder so that the diameter at the corner merges with the finished diameter of the work.

C. How to Turn Filleted Corners

1. Set up lathe with round nose turning tool or filleting tool ground to the required radius.

2. Rough face the shoulder almost to the scribed line (so that the approximate length is reached). Rough turn excess material left by the turning tool at corner of shoulder.

3. Finish turn the diameter of the work to the required size with the round nose tool. When proper depth of cut has been reached, set the graduated collar on the cross slide at "zero."

4. Disengage the longitudinal feed before the tool reaches the shoulder. Move the carriage slowly and carefully by hand until the tool cuts a slight amount off the face of the shoulder; then lock the carriage and feed outward.

   NOTE: Decrease the spindle speed to overcome chatter and to prevent the radius tool from digging in at the corner.

5. Measure length of work to shoulder. Take additional cuts on shoulder to face the work to the required length by first moving tool to the zero setting on the graduated collar and then facing outward.

D. How to Turn Beveled or Angular Shoulders

1. Finish turn diameter of work to required size and leave sufficient material at the corner to form the angular shoulder.

2. Set up lathe with the chamfering tool ground at the required angle.

   NOTE: A square nose tool or a facing tool set at the required angle may also be used for this purpose.

3. Feed the tool in to remove the excess material at corner of shoulder.

4. Set the graduated collar on the cross slide at "zero" when the end of the tool barely touches the finished diameter of the work.

5. Decrease the spindle speed of the lathe to overcome chatter.

   NOTE: The chamfering tool and the square nose tool, when used like forming tools, should be operated at reduced spindle speed.

6. Move the carriage by hand and cut the shoulder to the required length.

OPERATION SHEET

Operation Sheet No. SL-1-7

HOW TO: Round and Chamfer Turned Edges

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Chamfering on the lathe is the process of turning a bevel in order to remove a sharp external edge. Chamfers may be turned with a specially ground chamfering tool, a square nose tool, or with the side of any turning tool. An edge may also be chamfered with a file. This method is commonly referred to as "breaking an edge."

Rounding corners is the process of turning a small radius on the ends of work to remove sharp edges. The rounded edge may be formed with a specially ground radius tool or it may be shaped by filing.

TOOLS AND EQUIPMENT: Engine lathe, steel rule, hermaphrodite caliper, mill file, chamfering tool and radius tool.

PROCEDURE: A. How to Turn a Chamfer

1. Set up the chamfering tool at the required angle in the lathe and adjust the cutting edge of the tool on center.
2. Lay off the width of chamfer on end of work using hermaphrodite calipers.
3. Reduce spindle speed of lathe on wide chamfers in order to overcome chatter.
4. Move the carriage by hand to bring the side of the tool against the revolving work and cut the chamfer to the required width.

   NOTE: To obtain a smoother finish, lock the carriage and feed the tool into the work by means of the cross slide.

B. How to Round a Corner with a Radius Tool

1. Set up the radius tool in the lathe, and adjust the cutting edge of the tool on center.
2. Reduce spindle speed of lathe, when turning with large radius tools.

3. Move the tool in so that the radius tool is in contact with the edge of the job.

4. Lock the carriage. Feed the tool into the work by means of the cross slide or with the compound rest set at an angle.

5. Remove tool marks with file. Polish with abrasive cloth.

   CAUTION: Always make sure that the file is provided with a handle securely fastened to the tang in order to prevent serious personal injury.

C. How to Round a Corner by Filing

1. Increase the spindle speed of the lathe.

2. Grip the file as for bench filing. With long regular strokes, file the edge of the revolving work to required shape.

3. Remove file marks with abrasive cloth.

OPERATION SHEET

Operation Sheet No. SL-1-8

HOW TO: Turn Grooves

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Grooving is the process of turning a channel or furrow on a cylinder. The shape of the tool and the depth to which it is fed into the work governs the shape of the groove.

Grooves are frequently cut at the end of threads or against shoulders in order to provide a channel into which the threading tool may run.

Where a grinding operation is to follow the turning process, a groove is cut at the shoulder to provide a clearance for the grinding wheel.

A "V" groove is used on pulleys for the "V" type belt.

TOOLS AND EQUIPMENT: Engine lathe, steel rule, hermaphrodite caliper, and outside caliper.

PROCEDURE:

1. Lay off location of groove from faced end of the work.

   NOTE: Layout dye is used to make the scribed lines more visible. The required location of the groove may be laid off by means of a hermaphrodite caliper.

2. Set outside caliper to diameter at the bottom of the groove.
3. Select grooving tool to cut desired shape.
4. Mount tool in lathe, set the cutting edge on center.
5. Reduce spindle speed of the lathe to overcome chatter.
6. Bring the tool within boundaries of the groove, by moving the carriage.
7. Slowly feed the tool into the work.

   NOTE: Use cutting lubricant to produce a smooth surface.

8. Stop the lathe.

9. Check the depth of the groove.

CAUTION: Stop the lathe each time the groove is checked to avoid catching the caliper on the revolving work.

10. Feed the tool to the required depth.

NOTE: Feed the tool against the sides of the groove if it is to be widened.

Grooving tools are sometimes ground narrower than the required width of the groove in order to prevent chatter.

OPERATION SHEET

Operation Sheet No. SL-1-9

HOW TO: File and Polish on the Lathe

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Filing is done to fit one part into another, to obtain a smooth finish, to round off sharp corners, to remove burrs, or to correct a slight error on a taper. A mill file with its single cut teeth is better suited for these operations.

When filing and polishing on the lathe, the spindle is rotated at higher speeds.

Polishing on the lathe is a finishing operation performed with abrasive cloth to produce a fine finish.

TOOLS AND EQUIPMENT: Engine lathe, mill file, file card, and abrasive cloth.

PROCEDURE: A. How to File on the Lathe

1. Adjust spindle of lathe to operate at twice the speed used for turning.
2. Lubricate tailstock center.
3. Move the carriage to the extreme right and remove tool post.
4. Select a mill file.

   CAUTION: Never use a file without a handle.

5. Grasp the handle of the file in left hand and guide the opposite end with the thumb and forefinger of the other hand.
6. Start the lathe.
7. Place the file on the revolving work, holding the file at a slight angle. Take long slow strokes at right angles to the work.

   NOTE: Release the pressure on the return stroke without lifting the file from the work.

8. Continue to move the file slowly over the revolving work, exerting a uniform pressure for the full length of the file.

   NOTE: Apply chalk to the face of the file to prevent pinning and clogging.

   CAUTION: Under no circumstances should the file be "rapped" on the ways or any part of the lathe.

9. Move the file along the surface of the work for each stroke so that each cut overlaps approximately one-half the width of the file. Continue until the entire surface has been filed.

10. Stop the lathe. Check the diameter of work at intervals along the filed surface.

    NOTE: Clean the file frequently and rechalk to prevent "pinning."

11. File to required size.

B. How to Polish on the Lathe

1. Select the correct grade of abrasive cloth and cut off a 1" wide strip about 6 to 8 inches long.

2. Set the lathe to high speed, or one step faster than for filing.

   NOTE: Be sure to lubricate the dead center well.

   There are several methods you can use to hold the abrasive:

   a. Place the abrasive cloth over a file and move it across the work piece as for filing.

   b. Wrap the cloth once around the work piece, and hold the ends. Move the cloth back and forth.

      CAUTION: Be careful that you do not come too close to the revolving chuck or lathe dog.

c. Wrap the cloth once around the work piece. Turn the toolholder backwards in the tool post. Fasten the ends of the cloth between the toolholder and the wedge. Now use the power feed to move the cloth back and forth along the work piece.

3. Apply a small quality of oil to the abrasive cloth.

4. Start the lathe. Place the file with the abrasive strip held against it on the work. Polish the surface by taking regular strokes as for filing.

   NOTE: Small jobs are polished by holding a piece of abrasive cloth over the job and applying pressure with the thumb and forefinger.

   CAUTION: Use a short strip of abrasive cloth when it is held by hand. Hold the abrasive cloth in such a manner as to prevent it from winding around the work, as this may cause injury to the operator.

5. Stop the machine and wipe the polished surface free of oil and abrasive particles. Check the diameter for size and straightness.

6. Continue to polish until the desired degree of smoothness is obtained. Use successively finer grades of abrasive cloth to produce more highly polished surfaces.

   NOTE: A surface which appears more brightly polished can be obtained by using dry abrasive cloth in the final stages of polishing. However, a finer grained and somewhat duller appearing surface can be produced by using oil in polishing. Oil on abrasive cloth tends to prevent deep scratches in the surfaces of the work.

OPERATION SHEET

Operation Sheet No. SL-1-10

HOW TO: Knurl on the Lathe

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Knurling is the process of impressing a raised figure upon a cylindrical surface by means of a knurling tool. The knurl is formed by forcing a hardened roll or pair of rolls against the sides of a revolving cylinder. The metal is forced outward against the roll as pressure is applied, and shaped to form either the diamond or straight line pattern depending on the type of knurl used.

TOOLS AND EQUIPMENT: Engine lathe, steel rule, hermaphrodite caliper, knurling tool, and file card.

PROCEDURE:

1. Mount work between centers.

   NOTE: Long pieces held in a chuck should be supported at the end by the tailstock center to withstand the pressure of the knurling tool.

   Center holes should be drilled as large as the size of the work will permit in order to provide a large enough bearing sufficient to withstand the added pressure caused by the knurling operation.

2. Scribe the boundaries of the knurled portion with a hermaphrodite caliper.

3. Set up the knurling tool in the tool post so that the knurls are approximately the same distance above and below the center line of work. Make sure that the faces of the knurls are set parallel to the side of the work.

4. Check the movable head of the knurling tool so that it is free to oscillate to accommodate any variation in the trueness of the revolving work.

5. Regulate the spindle speed of the lathe to revolve at slow speed in order to start impression of knurl.

6. Feed the knurling tool in so that the rolls touch the surface of the work. Start the lathe and force the knurls into the revolving piece.

NOTE: As the impression begins to take form advance the carriage slightly.

7. Stop the lathe and examine the impression to make sure that both knurls are "tracking" properly and that no double impression is being formed.

   NOTE: If the beginning impression is doubled, move the tool to a new spot on the work and start again.

8. Regulate the speed of the spindle and the feed of the carriage to obtain a medium speed and feed.

   NOTE: The impression should be started with both rolls on the work piece. The knurl should not ride over the end of the job.

9. Mesh the knurls with the started impression, then force the tool into the work. Engage the longitudinal feed and knurl to required length.

   NOTE: Using a stiff brush, apply a good grade of cutting oil to the surface of the work.

   CAUTION: Stop the lathe to remove particles of metal from the knurl. Under no circumstances should the revolving rolls or work be wiped with waste, cloth, or with the fingers.

10. Reverse the carriage, increase the pressure on the knurls and knurl to end of piece.

11. Repeat the operation until the full depth of knurl is reached and a clean cut diamond shaped knurl is produced.

    NOTE: Once an impression is started, feed the tool the entire length of knurl without stopping. Rings will be formed in the knurled surface if the feed is stopped while the job revolves. If the work is stopped and the pressure on the tool is not relieved, the piece may be sprung, or "thrown out" of trueness.

OPERATION SHEET

Operation Sheet No. SL-1-11

HOW TO: Thread on the Lathe

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Thread cutting on the lathe is a process of producing a ridge of uniform section by cutting a continuous groove around a cylinder as a cutting tool of required shape advances along the revolving work.

TOOLS AND EQUIPMENT: Engine lathe, center gauge, steel rule, cutting oil, thread gauge, test nut, 10" mill file, and thread stop.

PROCEDURE:

1. Check the diameter of the turned work piece with the drawing and determine the number of threads per inch to be cut.

2. Set the quick change gear box of the lathe to cut the required number of threads per inch.

   NOTE: For quick change gear lathes, set the levers at the positions indicated on the index plate.

3. Turn the compound rest toward the tailstock and clamp it at an angle of 30° with the cross slide.

4. Select threading tool and holder suited to the job at hand. Check angle of tool with center gauge.

5. Secure tool and holder in lathe tool post and set the point of the tool at the height of the lathe center.

6. Set the threading tool "square" with the work by placing the edge of the center gauge against the turned side of the work and adjust the tool until the cutting point fits the V-shaped notch in the center gauge.

7. Reduce spindle speed of lathe.

   NOTE: The speed should be about one-third to one-fourth that for turning. You will probably have to use the back gears to obtain this slow speed. The correct speed to use is one that permits you to control the movements of the cutting tool at all times. Beginners should use slower speeds until skill and good judgment have been developed. Fine-pitch threads can be cut at a faster speed than coarse threads.

8. Check to make sure that the feeds are disengaged. Feed change lever should be in neutral position.

9. The thread stop is placed in position.

   NOTE: Thread stop may be placed either in front of or in back of the cross slide, depending on its design.

10. Bring point of tool to work piece so that it barely touches. Adjust thread stop against cross slide and tighten.

11. Set the graduated collar on the compound rest feed screw to zero.

12. Then move the tool away from the work and clear the end.

13. Start the lathe.

14. Engage the split nut with the lead screw.

15. As the tool moves along the surface of the job, feed it in gradually until a light trial cut is taken.

    NOTE: When using thread chasing dial, the first cut is taken by engaging the split nut when a selected line on the dial coincides with the index line.

16. Back the tool away from the work and stop the lathe. Check the number of threads per inch with thread pitch gauge.

17. Return tool to a starting position slightly beyond the end of the work.

18. Turn the cross feed handle into thread stop. Feed the compound rest in .003 to .005 for the first 3 or 4 cuts.

19. Start the lathe, engage the half nuts and take the first roughing cut for the length of the thread.

    NOTE: Apply a small quantity of cutting oil in order to produce a smoother cutting action.

20. Withdraw the tool at the end of the thread by quickly turning the cross slide handle and simultaneously disengaging the half nuts while work is revolving.

NOTE: This will require some practice on the part of the student. If the tool is withdrawn after the work has stopped rotating, the chip will break the point of the tool.

21. Take successive cuts by decreasing the amount the tool is fed in for each. Cut until the full depth of thread is nearly reached.

    NOTE: At this point, clean the threads and check for size.

22. Continue to take light cuts until thread fits mating part or test nut.

23. Remove burrs with mill file.

OPERATION SHEET

Operation Sheet No. SL-1-12

HOW TO: Turn Angles with the Compound Rest

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: The primary purpose of the compound rest is to turn angles or bevels. However, the compound rest may also be used for turning and boring short tapers, on which the length of taper is limited to the movement of the slide.

TOOLS AND EQUIPMENT: Engine lathe, steel rule, protractor, and hermaphrodite caliper.

PROCEDURE:

1. Refer to drawing for angle of turned part and then determine setting required for compound rest. (Refer to Information Sheet No. IL-1-19.)

2. Loosen clamping nuts or screws on compound rest swivel slide. Swing the compound rest until the required graduation on the base coincides with the index line and then clamp in position.

   NOTE: The base of the compound is graduated in degrees so that it can be set at any angle to the center line or axis of the work piece.

   The angle at which the compound rest is set is determined in the following manner:
   (a) if the angle with the center line of the work is given, the compound rest is set to that angle;
   (b) if the included angle is given, the compound rest is set to one-half the given angle.

3. Lay off the boundary of the angled side by scribing a line around the job with the hermaphrodite caliper.

4. Mount the toolholder in the tool post so that the cutting tool will be approximately at right angles to the surface to be turned.

5. Adjust the point of the cutting tool to make sure that it is set exactly at the height of the lathe centers.

   NOTE: In angular turning, the point of the tool must always be set "on center," in order to reproduce the angle at which the compound rest is set.

6. Adjust the carriage and cross slide until the point of the tool just touches the work. Lock the carriage clamping screw to prevent the carriage from moving away as the cut is taken.
7. Move the cross slide feed screw to bring the tool in position for the depth of the first cut.
8. Feed the compound by hand to take a trial cut.
9. Check the angle with a protractor and adjust compound if necessary.
10. Return the tool to the starting position by turning the compound rest feed screw in the opposite direction.
11. Take a series of cuts until the tool just splits the layout line for the width of the angle.

NOTE: To prevent scoring or marring of the finished surface, the tool should first be backed away by means of the cross feed screw before returning the top slide to the original position.

OPERATION SHEET

Operation Sheet No. SL-1-13

HOW TO: Turn Tapers Using the Offset Tailstock Method

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: A taper can be defined as a gradual and uniform increase or decrease in the diameter of the work piece with respect to progressive length. The conical shape of the taper provides a wedging action that has many practical applications in the machine shop. The fact that it can be assembled and disassembled easily and is automatically self-aligning, makes the taper ideal for driving and holding drills, drill chucks, reamers, end mills, and milling arbors.

Two general methods of tailstock offset measurement will be discussed differing only in the degree of accuracy required. A common trait of both methods is distance of the tailstock center from the longitudinal center line of the lathe.

When adjusting the tailstock for a tapered cut, the operator should remember to move the tailstock toward the working side of the lathe to turn a taper with the small diameter at the tailstock.

Mention should also be made of the fact that taper turning by this method will probably require some trial and error cuts to achieve any degree of accuracy.

TOOLS AND EQUIPMENT: Engine lathe, dial indicator, and 6" steel rule.

PROCEDURE: A. Measurement with Scale (accuracy not an important factor)

NOTE: When making the calculation for distance of offset, be sure to deduct from the length of the taper the amount the center enters the work piece.

1. Move the tailstock to the area of the headstock with sufficient space to measure between the centers with a steel rule.

2. Adjust tailstock necessary distance by using adjusting screw located on tailstock base.

3. Check adjustment by measuring between witness marks on the handwheel end of the tailstock.

NOTE: An additional check is to measure the lateral distance between the centers.

B. Measurement with Dial Indicator (some degree of accuracy required)

1. Mount a dial indicator in the tool post.

2. Position the indicator so that the dial reads zero when in contact with the tailstock spindle.

   NOTE: Be certain that end play is taken up in the cross slide screw.

3. Use micrometer dial collar on cross slide to measure the movement of the amount of offset required.

4. Adjust the tailstock over with the adjusting screw until the indicator reads zero.

5. Recheck indicator reading when snugging up the adjusting screws.

OPERATION SHEET

Operation Sheet No. SL-1-14

HOW TO: Mount Work on a Mandrel

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: A mandrel, when pressed into a finished hole, provides centers on which the outer surfaces of the job may be turned. Mandrels may be pressed into position by using either an arbor press or by "driving" the mandrel with a soft-faced hammer.

TOOLS AND EQUIPMENT: Arbor press and mandrel.

PROCEDURE:

1. Select mandrel suited to the type of job and size of bored hole.
2. Wipe mandrel clean, make sure that the surface is free of burrs or score marks.

   NOTE: Roughness or abrasions on the mandrel may be removed with an oilstone.
3. Apply a thin film of oil on the mandrel body and in the machined hole.

   NOTE: Oil is used to prevent seizing and scoring as the mandrel is pressed into or out of the job.
4. Insert small end of mandrel into bored hole as far as it will go.

   NOTE: The large end of the mandrel has the size stamped on it.

   Mount work on mandrel so that pressure and direction of cut will be toward the large end of mandrel. This will tend to press the work on tighter as it is being machined, and lessen the possibility of slipping.
5. Raise ram of arbor press to accommodate the length of the mandrel and work. Select the size opening in the table plate that will give the greatest support to the work.

6. Place work and mandrel in an upright position on the table plate and center the end of the mandrel under the ram.

7. Hold the work in position with the left hand and lower the ram until it just touches the mandrel. Check to see that the mandrel is inserted squarely.

8. Adjust the lever to get best position for maximum leverage.

9. Force mandrel into the work by applying pressure on lever.

   NOTE: The amount of pressure to apply depends upon the part, its size, and nature of work. Just enough pressure should be applied to prevent the work from slipping on the mandrel when a cut is taken later. Too much pressure will tend to distort the part and enlarge the hole.

OPERATION SHEET

Operation Sheet No. SL-1-15

HOW TO:	True Work in the Lathe Chuck
COURSE OF STUDY:	Machine Shop Practice - Lathe Operation
INTRODUCTION:	Although a large number of operations common to lathe work are performed with the work held between centers, these same operations can sometimes be performed to better advantage when the work is held in a chuck. Operations such as drilling, boring, reaming, internal threading and counter-boring are common to chuck work, as well as the various external turning operations.
TOOLS AND EQUIPMENT:	Engine lathe, chalk, and four-jaw independent chuck.

PROCEDURE:

1. Adjust the chuck jaws to the approximate size of the job. Gauge the position of the jaws by the concentric grooves in the face of the chuck.

   CAUTION: Always remove the chuck wrench from the chuck after adjusting.

2. Remove burrs from end of job and place work piece in chuck.

3. Grip the work in the chuck by tightening a pair of jaws which are opposite (2-4) each other. Then tighten the other pair (1-3).

   NOTE: The work should be chucked just tight enough to hold it in the chuck, as further adjustment will be necessary.

4. Check to see that the jaws are located the same distance from the grooves marked on the chuck face when truing a round piece.

5. Turn the work by hand to determine whether work runs approximately true.

6. Start the lathe. Run at a slow speed.

7. Mark "high spots" on the work with a piece of chalk. The chalk is held in the right hand and is gradually brought toward the slowly revolving work until it comes in contact with it. The chalk mark will indicate the high spot.

NOTE: Hold the chalk steadily and firmly to overcome the tendency of moving the chalk in and out with the eccentricity of the job. The chalk may be steadied by resting against a toolholder.

8. Locate high spot and release jaw opposite chalk mark. Then tighten opposite jaw.

NOTE: If the chalk indicates a high spot on the work between two jaws, release the pressure on the two jaws opposite the chalk mark and then tighten the two other jaws.

CAUTION: Adjust one set of jaws at a time so that the job will not fall out of the chuck.

9. Continue to test and adjust until the work runs true. Then tighten each jaw in turn with equal pressure to hold the work securely.

NOTE: In truing, it will be noted that work is sometimes "skewed" in addition to running out eccentrically. That is to say, the work may be concentric near the chuck while the end runs out. This may be corrected by tapping the high side lightly with a lead mallet.

OPERATION SHEET

Operation Sheet No. SL-1-16

HOW TO: Use Draw-In Collets

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Round finish stock and work of regular shape can be conveniently chucked in the lathe through the use of draw-in collet chucks.

The draw-in collet attachment is assembled in the spindle of the lathe. The work is held in the collet and tightened in place by contracting the front opening as the collet is drawn in against the taper closing sleeve.

TOOLS AND EQUIPMENT: Engine lathe, lathe collet set, and draw-in collet attachment.

PROCEDURE: A. How to Assemble Draw-In Collet

1. Clean spindle bore and taper sleeve. Make sure they are free of burrs.
2. Insert taper sleeve in spindle and seat securely.

   NOTE: Be sure to screw on the spindle nose cap before inserting taper sleeve.

3. Lock spindle of lathe by engaging the back gears.
4. Select collet of size suited to the job.
5. Examine for burrs and wipe clean.

   NOTE: In order to obtain accurate results, the collet size should be the same as the work. While work that is a few thousandths over or under the collet size may be chucked, the accuracy and efficiency of the collet is impaired because the segmented sides will not bear evenly along the length of the work.

6. Insert collet in taper sleeve and turn until the keyway engages the key in the sleeve.
7. Clean threads in end of draw bar, wipe draw bar clean.

8. Extend draw bar through left hand end of lathe spindle.

9. Press palm of right hand against face of collet to keep it from being pushed out of taper sleeve.

10. Turn draw bar handwheel clockwise to engage the threaded end of the collet and draw in until end play is nearly taken up.

B. How to Chuck Work in a Collet

1. Remove burrs from end of work.

2. Apply a slight pressure with the left hand against the handwheel to extend end of collet beyond tapered seat.

3. Insert work in collet and allow it to extend far enough to permit machining.

NOTE: Turn work in collet to make sure it is not "skewed."

4. Steady work with right hand and turn handwheel clockwise with left hand until collet is seated in taper sleeve and work is firmly chucked.

NOTE: The draw bar should not be tightened any more than is necessary to grip the work securely enough to permit machining.

To release work from collet, simply turn handwheel counter-clockwise and push against end of handwheel to spring the collet open again.

OPERATION SHEET

Operation Sheet No. SL-1-17

HOW TO: Face Work Held in a Chuck or Collet

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Facing is very often done on the work piece while it is held and revolved in a three or four jaw chuck. Work held in a chuck can be more conveniently faced than work held between centers.

TOOLS AND EQUIPMENT: Engine lathe and steel rule

PROCEDURE:

1. Select a chuck of the size and type suited to the job.

2. Mount chuck on lathe spindle (refer to Operation Sheet No. SL-1-25).

3. Mount and true work in chuck (refer to Operation Sheet No. SL-1-15).

   NOTE: Place work in chuck with as little overhang as possible in order to prevent chatter.

4. Select facing tool suited to the job and fasten in tool holder.

   NOTE: Where a considerable amount of material must be removed and a roughing cut is necessary, a tool bit ground for rough turning may be used. If the tool is to be fed from the center outward, as in the case of a job having a machined hole, a right hand turning tool may be used. For finish facing, it is more desirable to start at the center, use a right hand tool and feed outward.

5. Adjust point of tool exactly on center.

   NOTE: When facing with an ordinary turning tool, set the toolholder approximately at right angles to the face of the work.

6. Adjust spindle speed of lathe.

7. Start the lathe.

8. Move the carriage toward the headstock until the point of the tool just touches the face of the revolving work.

9. Move tool in for roughing cut depth. Lock carriage.

10. Turn cross feed handle to move tool to edge of revolving work, complete the cut by hand.

11. Measure work to determine how much material must be removed.

12. Feed tool into depth for each successive cut by turning compound rest feed handle to advance compound.

13. Take finishing cut by starting tool at center and power feeding outward.

14. Break all sharp edges.

15. Center drill work piece as per print (refer to Operation Sheet No. SL-1-1).

16. Remove work from chuck, noting which two jaws were loosened in order to save time in truing opposite end.

OPERATION SHEET

Operation Sheet No. SL-1-18

HOW TO: Drill on the Lathe

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: A hole is frequently drilled to precede other machining operations, such as: boring, reaming, counterboring and tapping. The nature of work may require a hole to be drilled either from a solid or from a cored hole before any of these operations can be performed.

TOOLS AND EQUIPMENT: Engine lathe, drill, and steel rule.

PROCEDURE:

A. Operations Prior to Drilling

1. Mount a lathe chuck (refer to Operation Sheet No. SL-1-25).
2. Truing work in a lathe chuck (refer to Operation Sheet No. SL-1-15).
3. Facing chuck work (refer to Operation Sheet No. SL-1-17).
4. Drilling center holes (refer to Operation Sheet No. SL-1-1).

B. Drilling on the Lathe

1. Select a twist drill of size suited to the job at hand.

   NOTE: Only straight shank drills can be mounted in a drill chuck. Taper shank drills are mounted directly into the taper hole of the tailstock spindle.

2. Mount drill in tailstock spindle.
3. Slide tailstock up until point of drill is close to end of work.

   NOTE: Make sure that the spindle is back far enough in the tailstock body when starting to drill so that when the spindle is extended for depth of hole it will not become disengaged from tailstock feed screw.

4. Clamp in position.

5. Adjust spindle speed of lathe for cutting speed suited to material and size of drill (refer to Operation Sheet No. SL-1-24).

6. Start the lathe.

7. The drill should be advanced into the work piece, slowly, by turning the tailstock handwheel until the hole has reached its full diameter. Apply cutting oil.

   NOTE: Start drill carefully so that the point of the drill cuts concentrically with the center hole.

   If the hole runs out of true, bring the butt end of the toolholder against the side of the drill and hold it there. This will prevent the tool from "wobbling."

8. Back the drill out of the work occasionally to remove chips from flutes. Feed to required depth.

   NOTE: Do not force drill beyond its ability to cut freely.

   The depth of the hole to be drilled may be measured by the graduations on the tailstock spindle, or by measuring the movement of the spindle with a steel rule.

   CAUTION: Remove drill from tailstock before starting next operation in order to prevent personal injury that may result from brushing against the point of the drill.

OPERATION SHEET

Operation Sheet No. SL-1-19

HOW TO:	Bore on the Lathe
COURSE OF STUDY:	Machine Shop Practice - Lathe Operation
INTRODUCTION:	Boring is defined as the operation of enlarging and truing a hole with a single-point tool. The largest size boring tool or boring bar that will clear the hole should always be used to insure rigidity.
TOOLS AND EQUIPMENT:	Engine lathe, boring bar and holder, and inside caliper.

PROCEDURE:

1. Select largest size boring tool or boring bar that can be accommodated in the hole.

2. Mount boring tool in tool post, set cutting edge on center.

   NOTE: Where boring bar is used extend only far enough to clear length of hole to be bored.

   Also, check to make sure that the heel of tool does not rub and that the position of the cutting edge of the tool remains at the height of lathe center.

3. Adjust spindle speed of lathe (refer to Operation Sheet No. SL-1-24).

4. Move the carriage forward so that the cutting edge of the tool is close to the edge of the hole to be bored.

5. Start the lathe.

6. Take a trial cut for a short distance into the work piece.

   NOTE: If trial cut does not remove all the eccentricity, take additional trial cuts until the front of the hole runs true.

7. Stop the lathe.

8. Check the size of the hole with inside calipers.

   CAUTION: Calipers should never be used to measure revolving work.

9. Engage the longitudinal feed and take the first roughing cut to the depth of the hole.

   NOTE: Due to the tendency of a boring tool to chatter and spring away from the work under heavy cuts, the amount of feed may have to be decreased.

10. Check size of hole before taking each succeeding cut, then bore to size.

    NOTE: Check diameter of hole to make sure that it is not "bell mouthed." If the tool tends to spring away, take additional cuts at the same setting of the tool.

    If the boring tool chatters, decrease spindle speed and feed. Also, check gibs on cross slide and compound rest, adjust to eliminate all play.

OPERATION SHEET

Operation Sheet No. SL-1-20

HOW TO:	Ream on the Lathe
COURSE OF STUDY:	Machine Shop Practice - Lathe Operation
INTRODUCTION:	Reaming on the lathe is the process of sizing a hole to a given diameter with a reamer so that the hole is machined round, smooth and straight.
TOOLS AND EQUIPMENT:	Engine lathe, cutting oil, and reamer.

PROCEDURE:

1. Select reamer and type of holder to suit the job. Check reamer for size.
2. Mount reamer in tailstock in the same manner as for drilling.

   NOTE: Check the alignment of the tailstock when reaming especially when the reamer is held in a chuck. The end of the reamer should be aligned with the mouth of the hole.

3. Reduce spindle speed to approximately one-half the speed used for drilling.
4. Move the reamer up into position so that the cutting end is supported on the edge of the drilled or bored hole.
5. Start the lathe and at the same time turn the tailstock handwheel to feed the reamer in the hole.

   NOTE: Use a cutting lubricant for the material being reamed.

6. Feed reamer through the work or to the required depth.
7. Stop the lathe and remove the reamer from the work.
8. Check reamed hole with inside calipers or other measuring device.
9. Break sharp corner of reamed hole.

OPERATION SHEET

Operation Sheet No. SL-1-21

HOW TO: Tap on the Lathe

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: The best and simplest way to cut internal threads is with a tap. The work piece should be held securely in a lathe chuck. The hole to be tapped and the tailstock center must align perfectly with the center line of the lathe.

TOOLS AND EQUIPMENT: Engine lathe, tap, tap wrench, and cutting oil.

PROCEDURE:

1. Select tap and tap wrench of required size.

   NOTE: Hand taps are designed for reversing in order to clear out the chips.

   Machine taps are designed for continuous tapping.

2. Fasten tap in tap holder.
3. Move tailstock up toward work to accommodate length of tap and clamp tailstock in position.
4. Mount tap between work and tailstock center.
5. Engage back gears (or any other method of locking spindle), to prevent spindle from turning.
6. Turn tap into work and at the same time turn the tailstock handwheel.
7. Enough pressure should be exerted at the start to make the tap catch the thread and prevent it from reaming the material at the front of the drilled hole.

   NOTE: Be sure to use thread cutting lubricant.

8. The hole is tapped to required length.

   NOTE: A started tap will feed itself into the work when turned.

   Additional pressure is not necessary to feed the tap. The tailstock center is used to follow the tap as it advances and to keep it in alignment.

9. If the hole to be tapped is a blind hole, a plug or bottoming tap should be used.

   CAUTION: Care should be taken when tapping blind holes. Avoid forcing the tap near the bottom of the hole, causing it to break.

10. Chamfer end of threaded hole to remove any burrs raised in tapping.

11. Check for fit, with a gauge or mating part.

OPERATION SHEET

Operation Sheet No. SL-1-22

HOW TO: Cut-Off Stock on the Lathe

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: "Parting" or cutting-off is the process of machining a groove around a revolving work piece in order to part it from the piece held in the lathe chuck.

TOOLS AND EQUIPMENT: Engine lathe, steel rule, cutting oil, and parting tool.

PROCEDURE:

1. Select a cut-off tool which will meet the requirements of the job.
2. Mount the cut-off tool with the cutting edge at the height of the tailstock center.
3. Square the tool with the work so that the sides will not rub in the groove.

   NOTE: If an inserted type blade is being used, adjust the blade in the holder so that it extends 1/32" more than half the diameter of the work. Clamp the holder "short."
4. Spindle speed of the lathe must be reduced.

   NOTE: Cutting speeds for "parting" are reduced approximately one-half to two-thirds of those used for turning the same type of material.
5. Make sure that all the "play" has been removed from the compound rest and the cross slide. Adjust gibs, if necessary.
6. Move the carriage to the approximate location for cutting off.
7. Measure length of work piece to be cut off by placing the edge of the rule against the work with the end of the rule "butted" up against the cutting edge of the tool.
8. The carriage should then be adjusted so that the tool is in position for the required length to be cut off.

9. Lock the carriage, this prevents it from moving.

   CAUTION: Never try to cut off the work piece when turning between centers.

10. Start the lathe.

11. Slowly feed the parting tool into the work piece.

    NOTE: Grip the cross feed handle with both hands, in this manner you will be able to feed the tool steadily and uniformly.

    Apply plenty of cutting lubricant.

12. Continue to feed the tool into the work piece until it is parted.

    NOTE: If the tool hogs in, turn off power and reverse the spindle by hand. Back out the cutting tool with the cross feed.

    Before the cut is completed, use a file to break all sharp edges.

OPERATION SHEET

Operation Sheet No. SL-1-23

HOW TO: Change Feeds on the Lathe

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Feed is the distance the tool advances for each revolution of the work. If a 1/32-inch feed is used in turning, it will require 32 revolutions of the work to turn a distance of 1 inch.

TOOLS AND EQUIPMENT: Engine Lathe

PROCEDURE:

NOTE: The quick change gear box is arranged between the spindle and the lead screw. It contains gears of various ratios which makes it possible to machine a variety of screw threads. The same gears may be used for the carriage longitudinal (feed) movement.

1. Select the feed in thousandths required.
2. Move the tumbler lever into the hole directly below the selected amount of feed.
3. Set shift levers into positions as per instructions on the index plate.

NOTE: The large numbers on the plate indicate the number of threads per inch, while the smaller figures indicate the feed of the carriage, in thousandths of an inch.

CAUTION: Before turning on lathe, be sure all levers are fully engaged. Check by turning the headstock spindle by hand.

OPERATION SHEET

Operation Sheet No. SL-1-24

HOW TO:	Change Spindle Speeds on the Lathe
COURSE OF STUDY:	Machine Shop Practice - Lathe Operation
INTRODUCTION:	The spindle controls the speed of the work piece. Power for driving the spindle is provided by an electric motor. There are four common methods of changing speeds on the lathe. They are (1) Flat Belt Drive, with three or four step pulleys; (2) Geared-Head Drive; (3) Variable Speed Drive; and (4) Hydraulic Drive.
TOOLS AND EQUIPMENT:	Engine lathe.

PROCEDURE: A. Flat Belt Drive

1. Loosen belt with belt tension handle.

   CAUTION: Lathe must be stopped before speed changes are made.

2. Open hinged cover that encloses the headstock cone pulley.

3. Place flat belt on desired step on step pulley.

4. Tighten belt by moving belt tension lever in the down position.

   CAUTION: Be sure your fingers are not on the headstock pulley belt when you tighten belt; you can pinch your fingers if they get caught between the belt and step pulley.

   NOTE: Belts which are allowed to run loose will creep and slip and cause an overall loss in cutting efficiency of the lathe. Report any loose or slipping belt to your instructor.

5. Close hinged cover.

B. Geared-Head Drive

CAUTION: Spindle must be stopped before gears are shifted to speed desired.

1. Select speed change by shifting change levers to desired position.

NOTE: Geared-head lathes are not all of the same design. You will have to check shifting lever instruction plate on the machine which you are operating.

If gears do not mesh properly, turn the spindle by hand (or use jog button, if your machine has one) until the shifting levers move into proper position.

C. Variable Speed Drive

CAUTION: With this type of system, the motor must be running while speed changes are made.

1. Turn speed selection handwheel, at the left side of the lathe, for spindle speed desired.

D. Hydraulic Drive

1. Turn speed control dial to R.P.M. wanted.

NOTE: Speed dial may be set to desired R.P.M. while spindle is running; when spindle is stopped, clutch will automatically shift to R.P.M. set.

2. Start lathe.

OPERATION SHEET

Operation Sheet No. SL-1-25

HOW TO: Mount a Lathe Chuck

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: Chucks hold work by means of jaws which may be adjusted to accommodate work of varying size or shape. Chucks are equipped with adapter plates which fit three types of lathe spindles, the threaded nose spindle, long taper key-drive spindle nose and the cam-lock drive.

TOOLS AND EQUIPMENT: Engine lathe, lathe chuck, and cradle block.

PROCEDURE:

1. Select a chuck of the size and type suited to the job.
2. Clean the hole of the chuck adapter plate.

   NOTE: If adapter plate is threaded, use a spring thread cleaner. All other adapter plates, wipe inside with clean rag.

3. Wipe spindle nose clean, remove any dirt or chips.

   NOTE: Sometimes the spindle bore is plugged with waste to prevent chips from entering.

4. Use a "cradle block" or board to support the chuck.
5. Move chuck up against spindle nose.

   NOTE: If spindle nose is threaded, turn spindle with left hand to engage the threads. Screw chuck on spindle by hand. Do not force or jam chuck too tightly against the shoulder.

   If the spindle has a standard key-drive taper nose, it has a substantial driving key and a large locking collar which screws onto the chuck as it is slid onto the taper.

   With a spindle nose of the cam-lock type, the chuck has projections which fit into 6 holes in the nose plate. Six clamps hold them securely. Each one must be tightened individually.

OPERATION SHEET

Operation Sheet No. SL-1-26

HOW TO: Grind Lathe Cutting Tools

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: The function of a cutting tool is to remove metal. The tool should do this work easily, at maximum feeds and speeds. The tool should retain its cutting qualities as long as possible.

The tool geometry, or cutting angles ground on the tool, plays an important part in machining.

Cutting tools will vary in shape to adapt them to various jobs. There are certain underlying principles governing their shape which apply generally. When these principles are understood, the grinding of lathe tools becomes comparatively easy.

TOOLS AND EQUIPMENT: Safety glasses, pedestal grinder, tool blank, and oilstone.

PROCEDURE:

CAUTION: Make sure tool rest is set about 1/16 inch from the wheel, for safety.

NOTE: Check face of grinding wheel to determine whether it needs truing or dressing.

Care must be taken when grinding a tool bit; do not overheat; dip it in water frequently.

1. Hold tool bit in right hand and steady it with the left hand.

2. Press the end of the tool against the revolving grinding wheel, move it back and forth to shape the end clearance angle (refer to Information Sheet No. IL-1-5)

3. Hold the left side of the tool bit against the face of the grinding wheel to form the side clearance angle and the end cutting edge angle.

   NOTE: Always move the tool back and forth across the face of the grinding wheel to get a uniform grind on tool angle.

4. Hold the top of the tool flat against the wheel to produce the side rake angle.

   NOTE: Side rake angle is that surface which forms the top of a tool and has been ground back at an angle sloping from the side cutting edge.

5. Hold the tool bit with the thumb and index finger of the left hand.

6. With the right hand, grasp the back end of the tool.

7. Hold the side cutting edge angle of the tool against the grinding wheel.

8. Move the back end of the tool in a swinging motion, right to left. The nose of the tool will follow the natural arc or radius.

   NOTE: Make sure the radius is the full length of the front clearance of the tool.

9. Check all the cutting angles for proper clearance.

10. Stone the cutting edge of tool on an oilstone.

OPERATION SHEET

Operation Sheet No. SL-1-27

HOW TO:	Use the Taper Attachment
COURSE OF STUDY:	Machine Shop Practice - Lathe Operation

INTRODUCTION: Taper attachments simplify the turning of tapers, boring tapered holes and the cutting of external or internal threads on tapered surfaces.

Permanently attached to a lathe, it in no way interferes with straight turning or other operations when not in use.

There are two types of attachments: the plain taper attachment and the telescopic taper attachment. This operation sheet will deal only with the latter.

TOOLS AND EQUIPMENT: Engine lathe with taper attachment, scriber, and layout dye.

PROCEDURE:

NOTE: Tapers are shown on most drawings in taper per foot in inches or degrees. On most attachments the graduations at the end of the swivel bar are divided into inches per foot on one end and in degrees (included angle) on the other.

1. Set the swivel bar to the correct amount of taper and tighten.

   CAUTION: Some lathe manufacturers have calibrated the swivel bar to be set at the angle with the center line, while other calibrations are designed to set the swivel bar to the included angle. Check with your instructor to determine the type of calibration the manufacturer has used on the lathe you are operating.

   NOTE: Notice that the right end of the bar is moved away from you if the small end of the taper is to be at the tailstock end of the work piece.

2. Layout the length to be tapered on the work piece.

3. Move the carriage until the attachment is centered along the length to be tapered. Be sure the total taper can be cut in one setting.

4. Lock the attachment to the bed.

5. Tighten the binding screw or clamp handle over the sliding block.

6. Make sure that the cutting edge of the tool is exactly on center.

   NOTE: If the tool is not on center, the angle of the cut will not be the same setting as the taper attachment.

7. Move the carriage to the small end of the taper until the cutting edge of the tool is about one inch past the end of the work piece.

8. Turn the cross feed until the cutting tool will take a light cut.

   NOTE: Remember that all the backlash must be removed from the cross feed screw and the taper attachment. If it is not eliminated, part of the cut will be straight.

9. Run the carriage in the direction of the taper by hand until the tool starts to cut the material.

10. Make several cuts until the taper is at least an inch long. With a rule carefully measure a unit of length such as 1 or 2 inches.

11. Measure the large and small ends at each point with a micrometer or outside calipers (refer to Information Sheet No. IL-1-12 and Information Sheet No. IL-1-15).

12. If necessary, readjust the taper attachment.

13. Finish turn the taper until the desired size is reached.

    NOTE: If the taper is to be ground, allow .008 to .015 inch for this operation.

OPERATION SHEET

Operation Sheet No. SL-1-28

HOW TO: Use the Tool Post Grinder

COURSE OF STUDY: Machine Shop Practice - Lathe Operation

INTRODUCTION: The tool post grinder is another of many attachments that makes the lathe extremely versatile allowing both internal and external grinding cuts. If proper precautions are taken, good results can be obtained. Generally, parts to be ground on the lathe are finished machined with an allowance of .010 to .015 inch for grinding.

TOOLS AND EQUIPMENT: Engine lathe, tool post grinder, diamond wheel dresser, and safety glasses.

PROCEDURE:

1. Mount tool post grinder in tool post.
2. Select wheel of proper material, size, and style to accomplish the job.

   NOTE: Before beginning any grinding operations it is of extreme importance to make provisions to keep abrasive dust from moving or sliding parts of the lathe. To do this, cover the ways with a heavy cloth. Place a vacuum line or a pan of water or oil beneath the wheel.

3. True and dress the wheel with a diamond dresser.

   NOTE: The diamond dresser should be located on or slightly below the center of the wheel.

4. Mount the work piece in the lathe.
5. Adjust the feed and speed of the lathe.

   NOTE: As a general rule, the speed should be about 80 to 100 R.P.M. and a feed of .005 to .007 inch. However, this depends to a large extent on the condition of the machine and the work.

6. Turn on power to lathe and grinder after making sure there is sufficient clearance.

7. Adjust grinding wheel until it just touches the work piece.

   NOTE: Take light cuts to avoid excessive pressure between the wheel and work piece.

8. Engage longitudinal feed.

9. Check work frequently with micrometer.

10. Redress wheel before taking final cut.

    NOTE: Be sure to take special care in cleaning the lathe upon completing the grinding process.

OPERATION SHEET

Operation Sheet No. SL-2-1

HOW TO: Cut Off Material

COURSE OF STUDY: Machine Shop Practice - Power Cut-off Operation

INTRODUCTION: Stock is round cut to length with either a power hacksaw or a continuous blade horizontal band saw. This Operation Sheet No. SL-2-1 will deal with the continuous blade type only.

TOOLS AND EQUIPMENT: Continuous blade horizontal band saw and steel rule.

PROCEDURE: NOTE: Refer to Information Sheet No. IL-2-2 for types and kinds of blades for power saws.

1. Make sure vise jaws are at right angles to saw blade.
2. Adjust the roller guide brackets so they are only slightly wider than the stock to be cut.
3. Place the material in the vise.
4. Lower the blade until it just clears the work.
5. Hold a steel rule against the edge of the saw blade and move the material until the correct length is obtained.

   NOTE: Always cut material 1/8" longer than required.
6. Tighten the vise and recheck length.
7. Start the saw.
8. Grasp the handle of saw frame and lower the blade slowly to start the cut.

   CAUTION: Never drop the blade quickly.
   Never apply extra hand pressure to the frame.

   NOTE: Use coolant if the machine has it.
9. Release hand from handle of saw frame, saw will now feed by itself.
10. The machine will automatically shut off when the cut is completed.
11. Recheck length of cut off material.

OPERATION SHEET

Operation Sheet No. SL-2-2

HOW TO: Saw to a Layout

COURSE OF STUDY: Machine Shop Practice - Band Machining Operation

INTRODUCTION: The vertical band saw is widely used in the metalworking trade. It is used for a great variety of sawing and machining operations. Industry has profited by its ability to remove excess material accurately and economically.

TOOLS AND EQUIPMENT: Vertical band saw

PROCEDURE: CAUTION: Wear safety glasses.

NOTE: Refer to Information Sheet No. IL-2-2 for types and kinds of saw blades.

1. Set vertical band saw to the proper speed for the type of blade and the material being cut.

   NOTE: Consult index plate or job selector on machine.

   Variable speed band sawing machines must be running to change speeds.

   CAUTION: If your machine has a gear shift control, you must stop the machine before changing the speeds.

2. Use the workholding jaw or a piece of wood to feed the work into the saw.

   CAUTION: Never crowd the blade.

3. Cut to within 1/32 of an inch of the layout lines.

   CAUTION: Do not talk to anyone while you are operating the saw; if you are not careful you could loose a finger.

   NOTE: When hand feeding, apply uniform pressure, develop a steady hand and a sharp eye to detect poor cutting performance.

OPERATION SHEET

Operation Sheet No. SL-3-1

HOW TO: Measure - Linear

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: Measurement in machine shop practice is an essential element in the accuracy of machining. Careful measurement of the work piece insures a correct fit and satisfactory operation of the mating parts. A good machinist must be able to measure with speed and accuracy.

TOOLS AND EQUIPMENT: Steel rule

PROCEDURE:

1. To measure a piece of stock, hold the work in your left hand and place the rule across the surface to be measured.

2. With the rule in your right hand, and using your thumb nail as a guide, extend the rule until the end is even with the left edge of the work.

3. Read the graduated markings on the rule from left to right and note which line on the rule coincides nearest to the right hand edge of the stock.

   NOTE: Select the edge of the rule which is graduated in fractional divisions of an inch in which the desired dimension is wanted. The most popular rule is graduated in eighths and sixteenths on one side and thirty-seconds and sixty-fourths on the opposite side.

OPERATION SHEET

Operation Sheet No. SL-3-2

HOW TO:	Saw with a Hand Hacksaw
COURSE OF STUDY:	Machine Shop Practice - Bench Work
INTRODUCTION:	The sawing of metal is one of the most common operations performed in the machine shop. Because the hacksaw is used by both skilled and unskilled workmen, it is more or less taken for granted. It does, however, require proper care and use.
TOOLS AND EQUIPMENT:	Hand hacksaw, bench vise, and steel rule.

PROCEDURE:

1. Place work in bench vise, the cut should be made about 1/4 of an inch from the vise jaw.

2. Select a blade suited to the material being cut (refer to Information Sheet No. IL-3-15).

3. Grasp the handle of the saw in the right hand and hold the frame with the left hand to guide the saw.

4. When starting the cut, apply the blade to the work to engage as many teeth as possible.

   NOTE: Start the cut easily, if you must begin on a sharp corner.

5. Apply pressure on the blade on the forward stroke to produce a cut.

6. Let up on the back stroke.

7. Take long steady forward strokes.

   NOTE: Avoid short strokes which will wear a part of the blade.

   CAUTION: Do not twist the blade in the work, it may break the blade.

   NOTE: Try to secure a uniform speed of about 40 to 50 strokes per minute.

8. Ease up on the forward pressure as the cut gets near the end of the piece.

   CAUTION: If the same amount of pressure is maintained at the end of the cut as is used during the cutting process, the saw blade will suddenly break through the material, resulting in serious hand injuries.

   NOTE: Refer to Information Sheet No. IL-3-15 for types and kinds of hand hacksaw blades.

OPERATION SHEET

Operation Sheet No. SL-3-3

HOW TO: Square a Work Piece

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: When layout measurements must be taken from the ends, it is sometimes necessary to square up these ends by hand filing. This method of squaring, by hand, is done only when machining is not necessary.

TOOLS AND EQUIPMENT: 10" mill file, bench vise, and combination square.

PROCEDURE:

1. Select the proper file (refer to Information Sheet No. IL-3-17).

   CAUTION: Do not use a file without a handle.

2. Clamp the work piece to be filed in the bench vise.
3. Grasp the file in one hand, thumb on top, fingers curled around the handle.

   NOTE: Avoid rocking the file, as this will produce an uneven or rounded surface.

4. Push the file and bear down on the forward stroke. Hold the file parallel to the surface to be filed.
5. Release the pressure and return the file to the original position for the next stroke.
6. Test the work frequently with a combination square to determine if the surface is straight and flat.
7. Repeat procedure no. 6 until end of work piece is square.

OPERATION SHEET

Operation Sheet No. SL-3-4

HOW TO: Use Layout Tools

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: Care should be taken in the use of layout tools so that sharpened and pointed edges are kept in good condition to prevent impairing the accuracy, which is essential to a good layout job. Tools which have pointed ends should be used only for the purpose for which they are intended.

TOOLS AND EQUIPMENT: Dividers, scriber, protractor, hermaphrodite caliper, combination square, center punch, and prick punch.

PROCEDURE:

A. Scriber

1. Inspect the point of the scriber to make sure that it is sharp.

   NOTE: If the point is dull, sharpen it on an oilstone by rotating the scriber between the thumb and forefinger while moving it back and forth.

2. Wipe the surface of the work piece to be scribed clean and free of oil, dirt and chips. Apply layout dye.
3. Place the steel rule flat on the work in position for scribing.
4. Grasp the scriber in the right hand as you would a pencil.
5. Hold the rule firmly by exerting pressure with the tips of the fingers of the left hand.
6. Incline the top of the scriber outward and set the point of the scriber as close to the edge of the rule as possible.
7. Scribe layout line by exerting pressure on the scriber and drawing it along the edge of the rule.

   NOTE: Incline the top of the scriber slightly in the direction in which it is to be moved.

B. Combination Square

1. Insert the blade through the slot in the head so that the round clamping groove in the blade engages with the end of the clamping bolt.

2. Extend the blade through the slot to the required length and clamp in position by tightening the knurled nut.

3. Place the square head against the work piece and scribe lines from the end or either side, according to the requirements of the job.

C. Protractor

1. Insert the blade through the slot in the swivel turret so that the rounded groove in the blade engages with the clamping bolt.

2. Extend the blade to the required length and tighten.

3. Loosen the clamping screw on the body of the protractor and swing the revolving turret to the desired angle. Tighten the clamping screw.

4. Place the base of the protractor against the side of the work piece and scribe layout lines as required.

D. Hermaphrodite Calipers

1. Be sure the scriber leg point is sharp. Sharpen point on oilstone if dull.

   NOTE: Adjust the length of the scriber leg so that it is even with the inside edge of the rounded caliper leg when it is to be used to scribe lines from the outside edge of the work piece. When scribing lines with the caliper reversed, set the scriber point to the full length of the caliper leg.

2. To set the caliper, loosen the lock nut slightly. The hooked leg is set on the end of the scale and the leg containing the scriber point is adjusted to the desired graduation on the steel rule. Tighten the lock nut.

3. Grasp the top of the caliper with the thumb and forefinger of the right hand.

4. Place the curved tip of the caliper against the surface from which the line is being located.

5. Keep the tip of the caliper leg square with the surface from which it is guided and in contact with the surface.

6. To scribe the line exert a slight pressure on the scriber and draw the caliper along the surface being scribed.

E. Center Punch & Prick Punch

1. Inspect the point of the punch. Make sure the point is sharp.

   NOTE: The point of a center punch is usually ground to a 90° angle. The prick punch has an angle of about 30°.

2. Hold punch in one hand, with the point on the scribed line at the place where it is desired to make indentation.

3. With punch in a vertical position, tap it gently with a machinist's layout hammer.

   NOTE: Tap the prick punch lighter than the center punch. The prick punch is used to identify layout lines and for making light indentations for the point of dividers. Where drilling is to be done, the center punch is used to help start the drill. The center punch will make a heavier indentation.

F. Dividers

1. Make sure the points of the dividers are sharp.

2. Set the dividers, place one point in the inch mark of the steel rule.

3. Turn the knurled adjusting nut with the thumb and forefinger. Adjust the divider until the point of the other leg is on the dimension you need.

4. To scribe a circle or arc, grasp the top of the dividers between the thumb and first finger of one hand.

5. Place the point of one leg on the punched mark.

6. Scribe a circle by swinging the free leg of the divider in a circular movement.

OPERATION SHEET

Operation Sheet No. SL-3-5

HOW TO: Layout

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: Layout is the transferring of information and dimensions from the drawing to the surfaces of the job. This is done by scribing or drawing lines to indicate the desired shape, location of holes or openings, angles, or any particular surface which requires machining, forming or bending.

TOOLS AND EQUIPMENT: Surface plate, scriber, combination square, layout dye, steel rule, protractor, file, prick punch and parallel bars.

PROCEDURE:

1. Study blueprint carefully to determine what information needs to be transferred to the work piece.
2. Remove oil and grease from work surface and apply layout dye.
3. Remove all burrs with a file.

   NOTE: The ends of the work piece should be made square, by machining or filing.
4. Always work from a given surface or base line, if possible.

   NOTE: A base line is one from which other required lines may be scribed.
5. Place the work on a surface plate so that all dimensions can be made from a flat surface. If this cannot be done, then the work may be raised by placing parallel bars underneath.
6. To lay out the location of holes to be drilled, first scribe the center line along which the holes are to be drilled. Then scribe a line at right angles to the center line at the correct location for the first hole (refer to Operation Sheet No. SL-3-4).

7. Prick punch the intersection.

   NOTE: If angular lines must be laid out, it may be done in one of two ways:
   (a) Set the correct angle by the use of a protractor.
   (b) Mark off the correct dimensions of the angle from two edges of the work piece, or from two lines at right angles. Then connect the two points by using a steel rule or straight edge and scribe along it to get the angle.

8. Parallel lines may also be scribed by using the combination square. Set the blade of the square at the desired dimension and scribe lines at each end of the work piece. Connect these lines with the steel rule or combination square placed on edge.

9. Right angle lines may be drawn by using the combination square or steel square. The blade is held at right angles to the work and the lines are scribed along the edge of the blade.

10. Check layout with blueprint for errors.

OPERATION SHEET

Operation Sheet No. SL-3-6

HOW TO: File

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: A file is a hardened steel cutting tool used by hand to finish, form, and remove metal. Filing is still an important part of machine shop work.

TOOLS AND EQUIPMENT: Bench vise, 10" mill file, chalk, and steel rule or combination square.

PROCEDURE: CAUTION: Never use a file without a handle.

A. Straight Filing

1. Place false jaws over steel jaws on bench vise.
2. Clamp work piece in the vise.
3. Select the proper file for the job.

   NOTE: Stand with feet slightly apart, with the left foot forward. The body weight should be balanced so that the arms may move easily forward and backward. You should be able to swing your arms and shoulders freely and comfortably.

4. Grasp the file handle in the right hand, thumb on top, fingers curled around the handle.

   NOTE: For heavy filing, the palm of the left hand should be placed on top and the fingers closed on the underside of the file.

   For light filing, hold the tip of the file with the thumb and first two fingers of the left hand, thumb on top, fingers below.

5. Apply pressure to point at start of stroke.
6. Press with both hands as center of file crosses work.
7. Apply pressure with right hand as end of file crosses the work.

8. Lift the file slightly on the return stroke.

   CAUTION: Do not drag the file back over the work or attempt to cut on the return stroke. This will dull the file.

9. Cover as much distance in one stroke as possible by moving the file sideways. Work from one end or side of work to the other.

   NOTE: Use a file card to clean the file. Particles of metal removed by the file frequently lodge in the teeth, these particles or "pins" may scratch the work if not removed with a file card.

10. Check the filed surface, for flatness, with a steel rule or combination square.

11. Chalk the teeth before final filing.

    NOTE: This helps to prevent material from clogging or being wedged between the teeth.

B. Draw Filing

   NOTE: Use a single cut file to produce a better finish.

1. Grasp the file firmly at both ends.

2. Push and pull the file sideways across the work.

3. Hold the file at right angles to the line of stroke.

4. Use the same pressure for both forward and return strokes.

   NOTE: Clean the file frequently. Chalk the file to prevent pinning.

5. Check the filed surface for flatness with a steel rule or a combination square.

6. Remove the sharp edge which results from draw filing. Hold the file at an angle and make a light stroke across the edge or corners.

   NOTE: Draw filing gives a smoother finish on edges and narrow surfaces than "straight" filing.

OPERATION SHEET

Operation Sheet No. SL-3-7

HOW TO: Thread with Hand Dies

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: Hand dies are used to cut screw threads on external diameters such as bolts or rods. It is a tool with an internal thread and is turned or screwed on to the round work piece. As the die is advanced, the teeth of the die cut the thread.

TOOLS AND EQUIPMENT: Die, die stock, and cutting oil.

PROCEDURE:

1. Clamp work piece securely in a vise.

   CAUTION: Use soft jaws on (machined) surfaces to protect the finish.

2. Select proper die as per print. Fasten the die firmly in the die holder with the size markings on top. The opposite side of the die threads are tapered so that it is easier to start the die.

3. Apply a few drops of cutting oil on die threads and place the die squarely over the end of the rod.

4. Place one hand on the die, apply downward pressure, and turn the die with the other hand until the thread takes hold. Continue for several turns.

   NOTE: It is important at this point to check to make sure that the die is cutting square with the work. Correction must be made now or the thread will be ruined.

5. To correct misalignment of die, back off approximately one-half turn then apply extra pressure on the handle which was high in relation to the horizontal. Make another complete turn on the work to produce a new thread.

6. Check as before, then apply more cutting oil and continue to cut the threads. Turn the die back, approximately one-half turn, frequently to clear away chips.

NOTE: The use of cutting oil is important to the finish on threads and the life of the die. Flooding of the work is not necessary, as that portion of the oil that runs off is not used, it is only wasted and creates a clean-up problem.

7. After the thread is cut to length, remove the die by turning it counter-clockwise.

8. Check the thread with a gauge or the mating part. If the thread is too large or too tight, close the die slightly by backing out the set screw in the die slot and tightening the opposing set screws in the die stock. Run the die over the thread again. It may be necessary to repeat this procedure once or twice to size the thread correctly.

OPERATION SHEET

Operation Sheet No. SL-3-8

HOW TO: Use the Micrometer Caliper

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: In all machine shop work it is important to develop a sensitive touch or feel. This is especially important when using precision measuring instruments such as the micrometer. Your sense of touch is very keen in your finger tips. Therefore, when adjusting the micrometer, use only your fingertips to set the measurement. Before you can acquire the proper sense of feel, it is necessary to hold and use a micrometer correctly.

TOOLS AND EQUIPMENT: Micrometer and work piece.

PROCEDURE:

1. The micrometer is held in the palm of the right hand by grasping the frame with the third or little finger, whichever is more convenient. The thumb and forefinger are free to revolve the thimble for the adjustment.

2. Place the work between the anvil and spindle.

3. Turn the thimble down until a light contact is made between the anvil and spindle.

   NOTE: A sense of "feel" in adjusting the micrometer to the work must be developed. Avoid the tendency to "cramp" the micrometer by using too much pressure.

4. Move the work slightly between anvil and spindle. This helps to square and align the piece being measured.

5. Remove the micrometer from the work piece.

   NOTE: You may wish to tighten the lock nut before reading the micrometer, although this is not necessary unless you wish to preserve the setting for a purpose.

✓

6. The measurement is taken from the graduations on the barrel and thimble (refer to Information Sheet No. IL-3-3).

7. Repeat steps 2, 3, 4, and 5 to recheck diameter of work piece.

OPERATION SHEET

Operation Sheet No. SL-3-9

HOW TO: Chip with a Cold Chisel

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: Chipping is an operation which requires some degree of skill and cannot be acquired except through proper manipulation of the chisel. There are four kinds of chisels used in machine shop work. These chisels are made from high grade carbon tool steel and are produced in many different sizes.

TOOLS AND EQUIPMENT: Cold chisel and ball peen hammer.

PROCEDURE:

1. Clamp work piece securely in a vise. Use soft jaws to protect finished surfaces.

2. Select the hammer suited for the job.

   NOTE: Hammer weights ranging from 16 oz. to 32 oz. will generally take care of most chipping jobs. Hold the hammer at the end of the handle and grasp it by the thumb, second, and third fingers with the first and fourth fingers closed loosely around the handle. The hand does not tire as quickly as when the handle is grasped tightly by all four fingers.

3. Grasp the chisel firmly enough to guide it but not tight enough to absorb the shock of the hammer blows. The head of the chisel should be about 1 inch above the thumb and first finger. These two fingers should be slack as the muscles are then relaxed and the fingers and hand are less likely to be injured if struck with the hammer. The second and third fingers grip the chisel firmly.

4. Hold the chisel on a slant or at an angle that will allow the cutting edge to follow the desired finished surface. A shallow cut can be made by lowering the head or a deeper cut made by raising the head. After each blow of the hammer, the chisel will need to be re-set to the proper position for the next cut.

   CAUTION: When chipping always cut away from other workers or keep a wire shield between the job and other workers.

OPERATION SHEET

Operation Sheet No. SL-3-10

HOW TO: Polish

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: Polishing of metal surfaces is accomplished by wearing or cutting away the metal. The abrasive material used in polishing is harder than the metal to be polished and is available in various grit or grain sizes. Polishing improves the appearance of the work.

TOOLS AND EQUIPMENT: Abrasive cloth, cutting oil, 10" mill file, and file handle.

PROCEDURE:

1. Place work piece in vise or holding fixture.
2. Obtain a strip of abrasive cloth of the desired grit size. This strip should be slightly wider than the width of the file and long enough to cover the length of the file face with sufficient excess to allow the strip to be folded over the tip of the file.

   NOTE: The machine finish on the work will determine the grade of abrasive cloth that should be used first.
3. With the abrasive cloth backed up by the file, place it on the work surface to be polished. Apply a downward pressure on the cloth and rub back and forth in a straight line across the work surface. Do not rock the file. Keep the file flat on the work surface.
4. Deep scratches or marks can be removed easier if a coarse abrasive is used first. Then follow with medium grain size and finish polishing with fine grain cloth. Cutting oil is recommended to be used with each grade of cloth as it helps the abrasive to cut faster.
5. When all the scratches have been removed, reverse the cloth so that the smooth side will be against the work. Add a few drops of oil and rub the surface for a high polish.

OPERATION SHEET

Operation Sheet No. SL-3-11

HOW TO: Tap by Hand

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: Hand taps are used to cut screw threads on internal diameters. They are made in all standard diameters and pitches. A standard set consists of three taps, each of which has a different starting taper.

TOOLS AND EQUIPMENT: Tap, tap wrench, and cutting oil.

PROCEDURE:

1. Clamp the work securely in a bench vise making sure that the hole is in a vertical position.

2. Select a tap with the proper taper and clamp it in the tap wrench.

   NOTE: The T-handle tap wrench is used for small taps and the adjustable tap wrench for larger taps.

3. Hold the tap wrench with your right hand cupped directly over the tap and place the end of the tap in the hole. Position the tap squarely in the hole and apply steady downward pressure while turning the wrench, to the right, two turns.

4. Loosen the wrench and remove it without disturbing the tap. Check to make certain the tap is started straight by using a small square at two points 90° to each other. If tap is not straight, back it out of the hole one turn, then exert pressure in the opposite direction, and turn the tap back into the hole two or three turns. Check again for squareness.

   NOTE: If the tap is not started straight it will cut more stock from one side than from the other and will eventually bind and break. Thus the result will be a broken tap and a ruined job.

   Two or three starts may be required before the tap will be positioned correctly.

5. Apply cutting oil to the threads and continue to turn the tap into hole. It is not necessary to continue with downward pressure as the tap will pull itself in. It is good practice to back off the tap about one-half a turn after one or two revolutions as this action will break the chips, avoids clogging the flutes and prevents breaking the tap.

6. Continue turning tap forward and backwards until the thread is completed.

   NOTE: When tapping a blind hole, it is necessary to use a tap set. Start with a taper tap, follow with a plug tap and finish with the bottom tap.

OPERATION SHEET

Operation Sheet No. SL-3-12

HOW TO: Burr an Edge

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: A burr is the turned-up or projecting edge of metal which results from drilling, sawing, and the general processes of metal cutting. Careless handling, nicking and dropping are common causes of burrs. Damaged or spoiled work is often caused by burrs not being removed before clamping the work in a machine, or before measurements are made. Burring is done to insure accuracy, safety in handling, appearance, and fit.

TOOLS AND EQUIPMENT: Bench vise and 10" mill file.

PROCEDURE: CAUTION: Personal injury may result from burrs and sharp corners. Be careful when handling!

1. Select the proper file (refer to Information Sheet No. IL-3-17).

   CAUTION: Be sure the file has a handle.

2. Clamp the work piece to be filed in the vise.
3. Hold file at a slight angle and push the file along the edge.
4. Inspect the work frequently.
5. Repeat step 3 until burr has been removed.

   NOTE: Be sure the work is free of burrs. Measurements taken over burrs are often a source of trouble. More accurate measurements can be made on work free from burrs.

OPERATION SHEET

Operation Sheet No. SL-3-13

HOW TO: Use the Pedestal Grinder

COURSE OF STUDY: Machine Shop Practice - Bench Work

INTRODUCTION: This type of grinding is called off-hand grinding because the work is held in the hand and controlled by the hands to shape or size it. The operator is protected against flying abrasive particles and ground material by the wheel guards. Safety glass shields are also provided for additional protection.

TOOLS AND EQUIPMENT: Pedestal grinder, wheel dresser, and safety glasses.

PROCEDURE:

1. Make sure tool rest is set on center with grinding wheel; also, it should be no more than 1/16 inch from the face of the wheel.
2. Adjust safety glass shields, if the grinder has this feature.

   CAUTION: Wear safety glasses, even though safety shields may be a part of the grinder.

3. Start the grinder.

   CAUTION: Stand to one side of the wheel, for about one minute; if a wheel should have a crack in it, it would fly apart by this time.

4. Hold the work in the right hand, and steady it with the left.
5. Place the work on the tool rest; then guide it against the face of the revolving wheel.
6. Apply enough pressure to grind the work piece, depending upon the hardness of the material.

   NOTE: Support the work on the tool rest to steady it when grinding. Tool bits can be better guided by supporting them with the left hand resting on the tool rest.

7. Cool the work in the water pot.

   NOTE: Do not overheat hardened tools--they can lose their temper.

8. Grind the job to the required shape or size by moving the work back and forth across the face of the grinding wheel. This will prevent wearing a groove in the wheel.

   CAUTION: Keep fingers away from revolving wheel. Make sure tool rest is close enough to the wheel to prevent the work from slipping into the space between the two.

   NOTE: Do not grind on the side of the wheel.

9. Check work.

10. Stop grinder.

DRESSING A GRINDING WHEEL

PROCEDURE: CAUTION: Wear safety glasses.

NOTE: Dressing is the operation of restoring the sharpness of the grinding wheel by breaking away the dulled abrasive grains, or by removing the loaded or glazed wheel.

NOTE: There are two common types of wheel dressers for off-hand grinders - they are: the abrasive stick and the disk-type, or star dresser.

1. Procure a mechanical wheel dresser.

2. Start the grinder.

3. Support the dresser on the tool rest so the point of contact is slightly above the center.

4. Tilt the handle upward at a slight angle.

5. Gradually apply pressure against the face of the revolving wheel.

6. Move the dresser back and forth across the face of the grinding wheel.

   NOTE: Hold dresser rigidly enough on the tool rest to maintain trueness while dressing.

7. Check the face of the wheel for a straight and sharp surface.

8. Repeat steps 5 and 6 until wheel surface is clean and straight.

9. Stop the machine and return the wheel dresser to its proper place.

OPERATION SHEET

Operation Sheet No. SL-4-1

HOW TO: Mill a Flat Surface

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: The milling operation determines the setup of the machine and the selection of the cutter. A flat horizontal surface is the first surface to be milled. A plain milling cutter should be selected. The cutter should be a little wider than the surface to be milled.

TOOLS AND EQUIPMENT: Horizontal milling machine, 10" mill file, and 6" steel rule.

PROCEDURE:

NOTE: See Operation Sheet No. SL-4-10, How to Mount the Work in the Milling Machine Vise; and Operation Sheet No. SL-4-9, Mounting the Milling Cutter.

1. Center the work piece directly under the cutter. Tighten the clamp that locks the saddle in position.

2. Adjust the table to bring the cutter to the right-hand end of the work.

3. Set the spindle speed selector, on the machine, for the desired R.P.M.

   NOTE: The methods of calculating speeds are covered in Information Sheet No. IL-4-5.

   CAUTION: Always stop the machine before making changes in the revolutions per minute of the spindle or reversing spindle.

4. Set the feed selector for the desired longitudinal feed.

   NOTE: The methods of calculating feeds are covered in Information Sheet No. IL-4-5.

5. Start the machine. Make certain that the cutter is revolving in the right direction and the work is clear of the cutter.

CAUTION: Keep hands and fingers away from revolving cutter.

Chips should not be removed from the table by hand.

6. Loosen the clamp that locks the knee.

7. Turn the vertical hand crank in a clockwise direction, raising the work piece fairly close to the cutter.

8. Continue more cautiously to bring the work to the cutter until it just touches.

   CAUTION: Operator should watch the cutter very closely while making this final adjustment, avoid cutting into the work.

9. Stop the machine.

10. Turn table traverse wheel to move the work from under the cutter and to permit setting the depth of cut.

11. Set the zero on the graduated dial of the knee to its index line.

    NOTE: If two sides are to be milled, half the metal should be removed from each side.

12. Turn the vertical hand crank in a clockwise direction until the number on the graduated dial corresponds with the number of thousandths that are to be removed from the work piece in one cut.

    CAUTION: Make sure the arbor support and the cutter clear the vise or hold-down bolts.

13. Start the machine, take a trial cut.

14. Feed the table, by hand, into the work for approximately 1/4" from the starting end of the work.

15. Stop the machine.

16. Turn the table traverse wheel in a counter-clockwise direction to back the work far enough away from the cutter to take a measurement of the work.

17. If the work piece measures too small, lower the table the desired number of thousandths. If the work piece is too thick, raise the table the desired number of thousandths.

18. Tighten the clamp that locks the knee in position. Start the machine.

19. Move the work to the cutter so that it just touches.

20. Engage the power table feed.

21. Use cutting fluid for steel (dry if the material is cast iron).

    NOTE: Do not stop feeding the work piece while the machine is cutting. If you do, the cutter will undercut at the point where you stopped the feed.

22. After the cut has been completed, stop the machine.

23. Check the surface.

    CAUTION: Never try to feel the finished surface while the cutter is revolving.

    NOTE: Never back the work piece under the revolving cutter. The milled surface will show several spaced undercuts, one for each revolution of the cutter.

24. With a brush, remove all chips from the work piece and surrounding work area.

25. Remove work piece from vise.

26. Remove burrs and sharp corners raised by the cutter, with a file.

27. Check milled surface for flatness.

OPERATION SHEET

Operation Sheet No. SL-4-2

HOW TO: Square and Indicate a Vise

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: To insure that the work will be machined accurately, the vise must be squared up with the machine spindle.

TOOLS AND EQUIPMENT: Milling machine, swivel vise, combination square, and dial indicator.

PROCEDURE: NOTE: Mount the vise on the milling machine table (refer to Operation Sheet No. SL-4-12). The bottom of the vise and the work table must be wiped clean of cuttings, or the clamping action will press the dirt into the metal and ruin the finished surfaces.

There are several ways of squaring a vise with the spindle. These will be explained individually.

A. Squaring a Vise with a Steel Square

1. Place the beam of the square against the face of the machine column.
2. Move the machine table in toward the square so that the solid jaw of the vise is opposite the blade.
3. Loosen the swivel clamp bolts and adjust the vise so that the jaw is parallel with the blade.
4. Tighten the clamp bolts and recheck the alignment.

B. Squaring a Vise on a Horizontal Milling Machine by Using the Machine Arbor.

1. Raise the machine table so that the arbor is between the two jaws.
2. Move the table by hand so that the solid jaw of the vise is against the arbor.
3. Loosen the swivel clamp bolts and adjust the vise so that the jaw is parallel with the arbor.

4. Tighten the clamp bolts and recheck the alignment.

C. Align the Vise with a Dial Indicator

1. Mount the dial indicator on the machine.

   NOTE: When using a vertical milling machine, the indicator is inserted into the Jacobs chuck.

   When using a horizontal milling machine, the indicator is clamped to either the machine arbor or the mounted cutter.

2. Raise the machine table so that the indicator plunger will be in line with the face of the solid jaw.

3. Move the table so that the solid jaw bears against the plunger enough to deflect the needle about .015.

4. Move the machine table so that the jaw moves along the indicator plunger. Observe the movement of the indicator needle.

5. Loosen the swivel clamp bolts, move the vise accordingly and recheck the needle movement. Two or three movements of the vise may be required before alignment is completed.

6. Tighten clamp bolts and make final check.

OPERATION SHEET

Operation Sheet No. SL-4-3

HOW TO: Drill on the Milling Machine

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: Milling machines - both vertical and horizontal - are used to produce precision holes in metal parts. Holes are more accurately located and aligned through the use of the table feed screws. These screws are equipped with micrometer collars. Hole depth is also controlled in the same manner.

TOOLS AND EQUIPMENT: Milling machine, Jacobs drill chuck, drill, center drill, and center finder.

PROCEDURE:

1. Secure the work piece in a workholding device.
2. Lower the work table to allow sufficient space for the insertion of the Jacobs chuck plus room for the drill.
3. Center the spindle over the location of the hole to be drilled by using a wiggler. Tighten horizontal table clamps to insure the maintaining of proper alignment.
4. Set the spindle speed and feed desired (refer to Operation Sheet No. SL-4-14).
5. Place the drill in the chuck and lower the spindle to make contact with the work.
6. Start the spindle and feed the drill into the work.

   NOTE: If a certain depth is desired, a stop can be set to stop the downward movement of the spindle.
7. When the hole has been drilled to the proper depth, raise the drill and stop the spindle.
8. Remove the drill and return to its proper place.
9. Remove work piece and clean the machine.

   CAUTION: Use brush to clean away chips. A cloth will pick up and hold chips. Using the same cloth to wipe hands will cause cuts and scratches.

OPERATION SHEET

Operation Sheet No. SL-4-4

HOW TO:	Calibrate on the Milling Machine
COURSE OF STUDY:	Machine Shop Practice - Milling Machine Operation
INTRODUCTION:	Calibrating means to divide into equal parts by engraving or cutting lines or graduations on a piece of metal. An example would be the graduations on a steel rule.
TOOLS AND EQUIPMENT:	Milling machine and engraving tool.

PROCEDURE:

1. Clamp work piece into workholding device.

   NOTE: Make sure working surface is free of obstructions.

2. Chuck up the engraving or scribing tool and lower the spindle until the tool touches the work.

3. Set the graduated dial on the spindle to zero, then move the tool off the job and turn the spindle down the desired depth for the graduated mark.

   NOTE: Usually a depth of .005 is sufficient when using a 30° pointed tool.

4. Move the point of the tool to the starting place. Set the graduated dial, of the table screw, to zero.

   NOTE: The use of the longitudinal or the transverse screws depends upon the direction the graduations are to be placed on the work.

5. Move the tool in the desired distance and return it to the starting point. Move the table the required distance and repeat the above operation.

   NOTE: The length and size of the calibrations are determined by the individual requirements.

6. Remove burrs and polish.

OPERATION SHEET

Operation Sheet No. SL-4-5

HOW TO:	Slot on the Milling Machine
COURSE OF STUDY:	Machine Shop Practice - Milling Machine Operation
INTRODUCTION:	Metal slitting cutters are called slitting saws. Slotting includes a variety of cuts in which various narrow slots are cut part way through the metal. Cut off operations are also performed with this type of cutter.
TOOLS AND EQUIPMENT:	Horizontal milling machine, slitting saw, and workholding device.

PROCEDURE:

1. Mount workholding device on milling table.
2. Clamp the work piece in the vise.
3. Select the cutter for the width slot required.
4. Mount the cutter on the arbor.
5. Set the feed and speed.
6. Raise the table until the work piece is fairly close to the cutter. Move the saddle in or out until the cutter is directly over the slot location.
7. Start the machine. Hold a thin, narrow strip of paper between the cutter and the work piece to act as a feeler. Raise the table until the cutter tears the paper.

   CAUTION: Keep the fingers away from the cutter by using a long piece of paper.
8. Set the micrometer collar at zero.
9. Move the table to the left of the cutter. Raise the table the correct depth of the slot or groove plus the thickness of the paper. Lock the knee.
10. Turn on the power, feed the cutter into the work and machine the slot.
11. Lower the table to clear the cutter, stop the machine and check the dimensions.

OPERATION SHEET

Operation Sheet No. SL-4-6

HOW TO: Counterbore on the Milling Machine

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: The operation of boring a hole larger in diameter, for part of its length, and concentric with the existing hole, is known as counterboring. The counterbore must be deep enough so that the screw or bolt head does not extend above the surface.

TOOLS AND EQUIPMENT: Vertical milling machine and counterbore.

PROCEDURE:

1. Mount the work piece in the workholding device.
2. Secure correct counterboring tool and mount in the toolholder.

   NOTE: For straight shanked tools, use a drill chuck; for tapered shank tools, use a sleeve or socket where required.

3. Start spindle and check for run out.
4. Set spindle speed at about one-half speed used for drilling.
5. Adjust spindle stop for required depth.
6. Lower counterbore to the hole, apply cutting oil.
7. Start machine and feed the counterbore slowly by hand into the work.

   NOTE: If the counterbore begins to chatter at the start, stop the machine and reduce the speed.

8. Raise the counterbore, stop the machine, and then check the hole for depth. Make any necessary adjustments to the spindle stop.

   CAUTION: Always stop the machine and allow enough working space to prevent injuries to the hands.

9. Return counterbore to hole and feed to required depth.

   NOTE: Use additional cutting fluid as needed.

10. Check final depth.

11. Return tool to storage area. Clean machine.

OPERATION SHEET

Operation Sheet No. SL-4-7

HOW TO: Ream on the Milling Machine (Vertical)

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: The purpose of reaming is to finish a previously drilled hole to exact size. Since drilled holes are not finished to close tolerance or fine surface finishes, it is essential that secondary operations follow drilling to meet these specifications.

TOOLS AND EQUIPMENT: Milling machine, safety glasses, vise or T-slot bolts and parallels and reamer.

PROCEDURE: NOTE: Hole to be reamed has previously been drilled (refer to Operation Sheet No. SL-4-3 and Operation Sheet No. SL-6-2).

1. Choose the correct reamer for the job and mount in cutter holding device in spindle.

   NOTE: If the vertical mill has a tapered shank spindle, a taper shank reamer may be inserted into the spindle. Use a drill chuck or adapter for straight shank reamers.

2. Reduce spindle speed one-half that used in drilling the hole.

3. Set the correct feed for reaming.

   NOTE: In reaming holes of 1/8 inch to 2 inch diameter in low-carbon steel, it would be well to start with a speed of 60 S.F.M. and a feed to 0.004 to 0.025 I.P.R. Speed or feed, or both, can then be increased until the first signs of tool chatter appear. At this point it is advisable to keep speeds and feeds below this point for best finish and tool life.

4. Start the machine.

5. With the vertical feed hand wheel or handle, lower the reamer slowly into the hole.

NOTE: Aligning the drilled hole with the reamer has already been done. The hole was drilled in the first operation and the table was not moved, hence the hole is still in alignment with the center of the spindle.

6. Continue to feed the reamer into the hole, by hand or machine feed. Apply cutting oil to the reamer.

   NOTE: Sometimes the reamer chatters. Chattering is caused by vibrations that are set up between the work and the reamer. It may be caused by a dull reamer, or the work piece or reamer may not be held rigidly enough. Check to see if any of these causes need correction. If not, try reducing the speed.

7. Now proceed with reaming the hole all the way through work piece.

8. Return spindle to starting position.

   CAUTION: The reamer should never be reversed as it is being removed from the hole, as this tends to break or dull the cutting edges.

9. Stop machine.

10. Remove the reamer from cutter holding device.

11. Remove piece from workholding device.

12. Return all tools and equipment to proper place.

13. Clean the machine.

OPERATION SHEET

Operation Sheet No. SL-4-8

HOW TO: Seat a Work Piece in a Vise

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: Any part that is to be machined on a milling machine must be held securely in a workholding device. The most frequently and certainly the most versatile workholding device used is the vise. It will hold many sizes of standard shapes, and the work can be secured or released quickly.

TOOLS AND EQUIPMENT: Milling machine and vise.

PROCEDURE:

1. Clean the vise jaws and the vise opening of all dirt and chips.

   NOTE: Clean surfaces are necessary for accurate machine work.

2. Compare the depth of the vise jaws with the height of the work to determine the necessity of using parallels. The work should extend above the vise jaws slightly more than is required for machining.

3. Place two narrow parallels between the vise jaws if required.

   NOTE: Two parallels are recommended because of the ease of measuring and ease of determining whether the work is properly seated.

4. Burr the entire piece and place on parallels or on the bottom of the vise. Place stips of paper under the four corners of the work piece.

5. Center the work in the vise and tighten the vise jaws. Apply enough pressure on the vise crank to hold the piece securely during the machining operation.

   NOTE: Exerting pressure on the vise jaws produces a lifting action. The movable jaw requires a small amount of clearance in order to function properly and the pressure causes it to lift, raising the work at the same time.

6. Tap the work lightly with a lead hammer or mallet to settle the work on both parallels until the paper feelers are tight. Use a hammer of leather or plastic on soft materials to avoid damage to the work.

   NOTE: The work will bounce or rebound from the parallels if struck too hard. Any movement of parallels is an indication that the work is not solidly seated. If the parallels are still loose, a heavier blow on the piece will force it down on the parallels.

   Further tightening of the vise, after seating, often tends to lift the work, and requires reseating it.

7. Return tools to proper place and prepare for machining operation.

OPERATION SHEET

Operation Sheet No. SL-4-9

HOW TO: Mount Milling Cutters

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: In general, milling cutters can be categorized into three groups which depend on the method of holding and driving. The selection of the proper cutter depends on the characteristics of the operation to be performed and the way in which the job is set up. In the discussion to follow we will be concerned with mounting each of the following varieties of cutters: arbor-type cutters, shank-type cutters, and facing-type cutters. Shank-type cutters (end mills) have straight or tapered shanks. Caution should be used in fitting tapered shank cutters to adapters because of the variety of tapers used.

TOOLS AND EQUIPMENT: Milling machine, wrenches, soft hammer, end mill, face milling cutter, plain milling cutter, and Allen wrenches.

PROCEDURE: A. Arbor-Type Milling Cutter.

1. Select the smallest diameter cutter of the proper style that will perform most satisfactorily.

   NOTE: In some cases this selection is not limited to a single type of cutter. The smallest diameter, however, will complete the job in less time.

2. Cover table surface with a cloth or board to protect it.
3. Select and mount an arbor that will accommodate the cutter selected.
4. Mount arbor as discussed in Operation Sheet No. SL-4-13.
5. Remove arbor nut.
6. Remove enough spacers to position cutter.

   NOTE: The cutter should be located as close to the column as possible.

7. Insert key in arbor keyway.
8. Mount cutter on arbor.

CAUTION: Cutter should slide freely on arbor; never force it on. Make sure cutter teeth will revolve in the proper direction. Protect your hands when handling cutters.

9. Place a 2" wide spacer next to the cutter followed by a bearing sleeve for the arbor support.

   CAUTION: Be sure all spacers are free from dirt and chips.

10. Add sufficient spacers to the arbor so they extend about 1/8" over the inner end of the thread.

11. Screw arbor nut on by hand.

    NOTE: Do not use wrench to tighten nut at this time; there would be a possibility of springing the arbor.

12. Loosen the overarm clamp and position the overarm so the arbor support can be mounted.

13. Lock the overarm in position.

14. Place arbor support on the overarm and locate the bearing sleeve centrally in the arbor support bearing.

15. Clamp the arbor support to the overarm.

    CAUTION: Make sure there is enough clearance between the arbor support and the vise or setup.

16. Tighten arbor nut with a wrench..

    CAUTION: Normal wrench pressure is sufficient, do not hammer on wrench.

17. Apply coat of oil to bearing surfaces.

    NOTE: Some arbor supports are equipped with oil reservoirs and they should be kept full.

18. Remove all equipment used in setup and return them to their proper places.

B. Shank-Type Cutter (Brown and Sharpe Cam Lock)

1. Select and mount the Brown and Sharpe Cam Lock arbor in the spindle as described in Operation Sheet No. SL-4-13.
2. Clean the tapered hole in the arbor.
3. Select the proper cam lock end mill.
4. Clean taper and cam throat on end mill.
5. Insert tapered portion of end mill into arbor.

   NOTE: Be sure cam throat is in position to receive the cam.

6. Using an Allen wrench, turn the cam lock clockwise to position and tighten the end mill.

   CAUTION: Remove Allen wrench from spindle.

7. Check the trueness of spindle rotation by starting the machine.

C. Facing-Type Cutters

1. Cover table surface with a cloth or board to protect it.
2. Clean spindle surfaces that contact cutter.
3. Clean cutter contact surfaces.

   CAUTION: Use a rag to protect hands while handling cutters.

4. Position cutter over spindle making sure driving lugs are located in the slots of the cutter.
5. Attach the cutter to the spindle using four fillister head screws.
6. Tighten screws with Allen wrench.
7. Start machine to see if the cutter is running true.

OPERATION SHEET

Operation Sheet No. SL-4-10

HOW TO: Mount the Vise on the Milling Machine

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: The vise is probably the most widely used workholding method used for milling operations. It is made in the plain style which can be fastened to the machine table with the jaws either parallel or at right angles to the T-slots. It is also made with a swivel base which allows the vise body to turn in a complete circle. The jaws are hardened to resist wear, and are ground for accuracy.

TOOLS AND EQUIPMENT: Milling machine and vise

PROCEDURE:

1. Clean surface of milling machine table free of all oil and dirt, and clean out the table slots.

   NOTE: A flat piece of steel, which is made to fit loosely in the slots, is used to keep the slots clean in order that clamping bolt heads can slip easily through the slots.

2. Turn the vise on its edge and wipe the machined surface clean. Remove any burrs that are found.

3. Insert tongues or keys into the vise slots, which will position the vise according to the jaw position requirement.

4. Place the vise carefully on the table, with the tongues fitted into the correct table slot.

   CAUTION: Request additional help when lifting the vise on to the milling table.

5. Place a square T-head bolt in the table slot on each side of the vise. Slide along the slot and into the vise slots.

6. Place a washer and nut on each bolt and tighten with a wrench so that the vise is clamped to the table.

CAUTION: Use a wrench that fits the nut.

NOTE: Be sure a washer is placed over the bolt before a nut is used. This will prevent the nut from marring the vise slot.

OPERATION SHEET

Operation Sheet No. SL-4-11

HOW TO: Dismount the Vise on the Milling Machine Table

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: A vise, plain or swivel, is the most used workholding device for a milling machine, but there are times when other methods are used. This requires the removal of the vise in order to make space for another type of fixture.

TOOLS AND EQUIPMENT: Milling machine and vise.

PROCEDURE:

1. Clean the chips from the vise and table.

   CAUTION: Never use your hands or a cloth to brush away chips. Use a brush and pan to collect them.

2. Loosen the nuts on the T-bolts and remove the bolts from the T-slots. Place them in their storage rack.

   CAUTION: Never use an adjustable wrench on the nuts.

3. Remove the vise from the table and place it in its storage area.

   CAUTION: Never attempt to remove a vise from a milling machine table without help. Permanent injury can result.

   NOTE: The storage area should have a wooden base to protect the machined area of the vise from damage.

4. Use the slot cleaner to remove the cuttings to the ends of the table. Finish cleaning the machine with a brush and pan.

5. Return all tools to their proper places.

OPERATION SHEET

Operation Sheet No. SL-4-12

HOW TO: Dismount Milling Cutters

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: When a job is completed in the machine shop it is customary to break down the setup and restore the work station to its original condition. One of the aspects of this clean up is to remove the milling cutter. Even though the cutter has been used to machine a job, it is still sharp enough to cause injury and should be handled with due consideration. It should be a common practice to check the condition of the cutter to determine whether it needs to be sharpened or not. If it does not require sharpening it should be stored in a location that will insure damage prevention. If the cutter is dull take the necessary steps to get it ground.

TOOLS AND EQUIPMENT: Milling machine, Allen wrenches, and wrenches.

PROCEDURE: A. Arbor-Type Milling Cutter

1. Loosen arbor nut.
2. Unclamp arbor support from overarm.
3. Remove arbor support from overarm.
4. Unlock overarm.
5. Move overarm back until its front is flush with the column.
6. Remove arbor nut.
7. Remove spacers and bearing sleeve.
8. Remove cutter.

   NOTE: Handle the cutter with a cloth.
9. Replace spacers, bearing sleeve, and arbor nut.
10. Remove arbor as discussed in Operation Sheet No. SL-4-13.

B. Shank-Type Cutter

1. Unlock cam using Allen wrench.
2. Remove cutter.

   CAUTION: Handle the cutter with a cloth.

3. Remove arbor as discussed in Operation Sheet No. SL-4-12.

C. Facing-Type Cutter

1. Loosen four fillister head screws with Allen wrench.
2. Remove cutter.

   CAUTION: Handle the cutter with a cloth.

3. Remove arbor as discussed in Operation Sheet No. SL-4-13.

OPERATION SHEET

Operation Sheet No. SL-4-13

HOW TO: Mount and Dismount Milling Machine Arbor

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: The arbor is the most commonly used cutter holding device used on the milling machine. It is made in several sizes, lengths and styles.

The friction or holding power of the taper provides the driving power for the arbor. The arbor is fitted with driving lugs for positive drive, and a threaded hole is provided to receive a draw-in bar to seat the tapered portion solidly in the tapered machine spindle.

TOOLS AND EQUIPMENT: Milling machine, arbor, draw-in bar, and wrench.

PROCEDURE: A. Mounting the Arbor

1. Protect machine table with cloth or wooden tray.
2. Clean the tapered end of the spindle thoroughly and check the spindle hole for dirt and chips.
3. Clean the threads on the end of the draw-in bar to keep chips from dropping into the tapered portion of the spindle, and also to prevent the threads from binding when inserted into the arbor hole.
4. Select the type of arbor required.
5. Clean and examine all over for nicks and burrs.

   NOTE: All burrs must be filed, or stoned, if the surface is hardened. A high spot or dirt will throw the arbor out of line and cause the cutter to "run out."

6. Insert the draw-in bar into the hole of the spindle from the back end of the machine.
7. Insert the arbor into the tapered end of the machine spindle.

   NOTE: Make certain that the arbor is seated properly and that the driving lugs on the face of the spindle are aligned with the slots on the collar of the spindle.

8. Stand at side of machine. Hold arbor with one hand and thread draw-in bar into arbor, with the other hand, until tight.

   NOTE: Damage can result if arbor is pushed from spindle and falls onto other tools or the unprotected machine table.

9. Lock the spindle by using the spindle lock or shifting into back gear.

10. Use wrench to tighten the nut on the draw-in bar.

    NOTE: Drawing the nut tight will draw the arbor securely into place.

11. Release the spindle and start the machine. The arbor should run perfectly true unless it is bent or there are some particles of dirt wedged between the arbor and spindle tapers.

B. Dismounting the Arbor

1. Lock the spindle. With the correct size wrench, loosen the locking nut on the draw-in bar.

2. Back the nut away a partial turn in a counter-clockwise direction.

3. Tap the end of the draw-in bar lightly with a soft hammer (refer to Information Sheet No. IL-3-8).

   NOTE: The standard milling machine spindle is designed with a steep taper so that the arbor will not stick in the spindle and can be easily and quickly released.

4. Unscrew the draw-in bar completely with one hand while supporting the arbor with the other.

5. Remove the arbor from the spindle and return to storage place.

6. Release spindle lock.

OPERATION SHEET

Operation Sheet No. SL-4-14

HOW TO:	Adjust Feeds and Speeds on the Milling Machine
COURSE OF STUDY:	Machine Shop Practice - Milling Machine Operation
INTRODUCTION:	The rates of feed and speed are governed to a large extent by such characteristics as material being cut, type of tool being used, ridigity of setup, type and condition of machine, and type of finish desired. Although most modern milling machines utilize a quick change gear box where the operator dials the speed and feed he wants, there are other methods used to control these variables. Two common methods are: shifting V-belts and adjusting variable speed pulleys. This operation sheet will be primarily concerned with the modern dialing process.
TOOLS AND EQUIPMENT:	Milling machine

PROCEDURE:

1. Calculate or determine from tables the amount of feed and speed required.

   NOTE: If the speed or feed required falls between two steps on the dial, set the speed or feed at the lower value.

2. By using the shift lever, dial to the speed or feed required.

   CAUTION: Make all speed and feed changes when the spindle is stopped.

   NOTE: It is important for the operator to realize that mechanisms for selecting speeds and feeds varies from machine to machine depending on the manufacturer. With this thought in mind, if any doubt exists in setting either speed or feed, consult the manufacturers instructions.

OPERATION SHEET

Operation Sheet No. SL-4-15

HOW TO: Bore a Hole on the Milling Machine

COURSE OF STUDY: Machine Shop Practice - Milling Machine Operation

INTRODUCTION: It is often necessary to enlarge a previously drilled or cored hole on the milling machine and this is generally accomplished by boring with a single point tool mounted in a boring bar or a micrometer adjusting boring head. The micrometer boring head simplifies what is normally a difficult task with the plain boring bar. The micrometer adjusting boring head incorporates a vernier scale so that accurate cuts can be taken.

TOOLS AND EQUIPMENT: Horizontal milling machine, ball peen hammer, boring bar or head, and inside precision measuring instrument and/or inside caliper.

PROCEDURE:

1. Mount boring bar or boring head in spindle.

   NOTE: A tapered shank boring head may be mounted directly in the spindle; straight shanks in a collet.

2. Mount and align work piece on table or in vise with respect to the spindle.

3. If work piece already has a pilot hole, center the work piece with respect to the boring bar.

   NOTE: Using a plain boring bar will necessitate a trial and error method for sizing the hole. To size the hole, loosen the set screw holding the tool and gently tap the tool outward. Tighten set screw. Start a trial cut; then measure.

   Some boring heads incorporate two cutting tools with a vernier adjustment only on the tool toward the spindle.

OPERATION SHEET

Operation Sheet No. SL-5-1

HOW TO: Shape a Horizontal Surface

COURSE OF STUDY: Machine Shop Practice - Shaper Operation

INTRODUCTION: The metal shaper was developed for the purpose of removing material to produce a flat surface. This surface can be machined in a horizontal, vertical, or angular plane. The work is held in a vise fixture, or clamped on the surface of the table, and a single point tool is driven back and forth on a horizontal plane to produce a flat machined surface.

TOOLS AND EQUIPMENT: Shaper, vise, and cutting tool.

PROCEDURE: CAUTION: Be sure you understand the operation of the machine thoroughly before you attempt to operate it.

1. Remove all burrs from the work piece.

2. Mount the work piece in the center of the vise (refer to Operation Sheet No. SL-4-9).

   NOTE: Keep sufficient material above the jaws to allow clearance of the cutting tool when machining the work.

   It may be necessary to support the work on parallels in order to place it above the jaws for machining.

3. Set the tool head in a vertical position and swivel the top of the clapper box in the same direction as the work is being fed.

   NOTE: This setting will allow the tool to swing away from the work on the return stroke.

4. Mount the single point cutting tool in the toolholder with the holder turned slightly away from the direction of feed, so that it will not dig into the work piece if it loosens.

5. Turn the slide up until it is even with the dovetail on the tool head.

6. Adjust the table up or down so that the surface to be machined is at least 2 inches below the ram.

   NOTE: To move the table up or down, loosen the cross rail bolts. Move to desired position, then tighten all bolts.

7. Move the work piece clear of the cutter.

8. Move the tool down the required depth.

   NOTE: Use the graduated collar on the tool slide screw to measure the downward movement of the tool.

9. Engage the automatic feed and take first or roughing cut. Return the work to the starting point. Continue to take cuts until the required dimension is achieved.

10. Remove from vise and file burrs.

11. Return tools to proper place.

12. Clean machine.

OPERATION SHEET

Operation Sheet No. SL-5-2

HOW TO: Adjust the Stroke and Position of the Ram

COURSE OF STUDY: Machine Shop Practice - Shaper Operation

INTRODUCTION: The method for adjusting and positioning the stroke of a shaper ram varies slightly for different makes, but the basic principles are the same. These adjustments are made after the work is secured in the workholding fixture and before the machine is started.

TOOLS AND EQUIPMENT: Shaper and steel rule.

PROCEDURE: A. Adjusting the Stroke

1. Measure the length of the work to be machined and add about three-quarters of an inch, to allow clearance for tool at each end of the stroke.

   NOTE: Clearance at each end of stroke means the tool will travel one-quarter inch beyond the front end of the work and one-half inch behind the back end of the work.

2. Start the shaper, move the ram to the return end of the stroke. Shut off machine.
3. Adjust the length of the stroke by placing the crank on square end of the stroke adjusting shaft, loosen the lock nut and turn the crank to move the ram.

   NOTE: The crank is turned in the direction that the ram is to be moved. A stroke indicator or finger is attached to the ram which will point to the number or length on a scale fastened to the main column of the machine. The number pointed to on the scale should be the same as that derived in step 1.

4. Tighten the stroke regulator lock nut.

B. Positioning the Ram

1. Start the shaper, move the ram to the return end of the stroke. Shut off machine.

2. Loosen the ram lock or clamp.

3. Adjust the ram forward or backward so that the tool is within one-half inch of the work piece.

   NOTE: The tool clearance at the extreme end of the forward stroke should be at least one-quarter inch beyond the work piece.

4. Tighten the ram lock or clamp so that the ram will stay in a fixed position.

5. Start the shaper and check the position of the ram, as it passes over the work, to see that the tool clears each end of the job.

OPERATION SHEET

Operation Sheet No. SL-5-3

HOW TO: Grind Shaper Tools

COURSE OF STUDY: Machine Shop Practice - Shaper Operation

INTRODUCTION: The shaper tool or cutter generally is a piece of hardened high grade steel which is shaped and ground to a cutting edge. It is held in the tool head and passed across the work in a series of cuts.

The shaper tool differs from the lathe tool because it requires less side and front clearance.

TOOLS AND EQUIPMENT: Grinder, tool blank, and safety glasses.

PROCEDURE:

1. Refer to Operation Sheet No. SL-1-26 Grinding Lathe Cutting Tools for grinding procedure.
2. Refer to Information Sheet No. IL-1-5 High Speed Single Point Cutting Tools for information on shaper tool clearance angles.

OPERATION SHEET

Operation Sheet No. SL-5-4

HOW TO: Adjust the Speed and Feed

COURSE OF STUDY: Machine Shop Practice - Shaper Operation

INTRODUCTION: The speed of a machine crank shaper is the number of cutting strokes made by the ram during one minute of operation. In horizontal shaping, the feed is defined as the distance the work is moved toward the cutting tool for each forward stroke. Since each make shaper employs a somewhat different method for setting the speed of the ram and the feed of the table, it will be impractical to explain all of them in this operation sheet. Therefore, procedures will be given on several of the common types only.

TOOLS AND EQUIPMENT: Shaper

PROCEDURE: A. Adjusting the Speed of the Ram

Procedure I:

1. Determine the cutting speed in feet per minute for the material being machined (refer to Information Sheet No. IL-5-3).
2. Select from the numbers on the stroke plate, the required number of strokes per minute.

   CAUTION: Do not shift gears when the clutch is engaged.
3. Shift the speed indicator by means of a lever into the slot adjacent to the selected number.
4. Shift back gear lever to position "A" or "B", the choice depending upon which of these letters precedes the speed selected.
5. Engage the clutch.

Procedure II:

1. Determine the cutting speed in feet per minute for the material being machined (refer to Information Sheet No. IL-5-3).

2. Select from the numbers on the stroke plate, the required number of strokes per minute.

   CAUTION: Do not shift gears when the clutch is engaged.

3. Set gear change lever positions (usually two levers) as indicated on the "strokes per minute" plate.

4. Engage the clutch.

B. Adjusting the Automatic Feed

Procedure I: Slide Block Type

1. Determine, in thousandths of an inch, the approximate amount of feed for the job (refer to Information Sheet No. IL-5-3).

2. Adjust the slide block out from the center of the feed disc or feed rocker arm, a distance estimated to produce the desired amount of feed.

   NOTE: The farther from center the block is moved, the greater becomes the amount of feed.

   If the slide block is moved out from the center of one side of the feed disc or feed rocker arm, the feed will operate during cutting stroke. If the block is moved out from center on the opposite side, the feed will operate on the return stroke. The latter adjustment is preferable for most work.

3. To determine the amount of feed for which the shaper has been adjusted, apply the automatic feed.

4. Start the machine.

5. Slowly engage the clutch. Note how many thousandths of an inch the micrometer dial on the cross feed screw advances for each stroke of the ram.

6. Continue to make adjustments of the slide block, if the first setting does not result in the desired amount of feed.

NOTE: The operation of the plunger-type pawl is described as follows:

When the pawl is lifted by means of the knob and turned one-half revolution, the ratchet wheel is caused to rotate intermittently in a clockwise direction, since the driving face of the pawl engage the opposite sides of the teeth. If the pawl is withdrawn from the engagement with the ratchet wheel, the automatic feed will not operate, although the pawl arm continues to oscillate.

Procedure II: Direct-Reading Feed Dial

1. Determine, in thousandths of an inch, the approximate amount of feed for the job (refer to Information Sheet No. IL-5-3).

2. Select from the numbers on the direct-reading feed dial, the one which most nearly corresponds with the selected feed in thousandths.

3. Move this number on the dial to the index line.

   NOTE: For each position of the feed selector, the dial immediately indicates the amount of feed in thousandths of an inch for each stroke of the ram.

OPERATION SHEET

Operation Sheet No. SL-6-1

HOW TO: Drill on the Drill Press

COURSE OF STUDY: Machine Shop Practice - Drill Press Operation

INTRODUCTION: Drilling is the operation of producing a round hole by removing solid material with a specially designed cutting tool known as a drill.

It is one of the most common machine shop operations and is performed on several different types of drilling machines to produce a variety of types and sizes of holes in metal and other materials.

TOOLS AND EQUIPMENT: Drill press, vise, and drill.

PROCEDURE:

1. Mount the work in a workholding device.
2. Adjust the table height and set the spindle speeds and feeds (refer to Information Sheet No. IL-6-6).
3. Select a drill of the proper size. Determine if it is ground correctly to cut the kind of material to be drilled.
4. Mount the drill in the drill chuck. Start the machine and observe how it runs.

   NOTE: If the drill wobbles, it may be bent or perhaps it is not seated correctly in the chuck due to burrs or chips.

   Make the adjustment, or replacement in the case of a bent drill, and tighten the chuck.

   CAUTION: Be sure to remove the chuck key before starting the machine.
5. Start the machine, lower the drill to the work, apply light pressure to start the point of the drill into the work. Release the pressure, raise the drill from the work and check to make sure that the drill is started in the correct location.

6. Lower the drill to the work, apply cutting fluid, start the machine and engage the feed.

7. Apply cutting fluid liberally and continue to drill to the required depth, raising the drill from the hole frequently to clean the flutes of chips. This also permits the lubricating and cooling of the point of the drill.

   CAUTION: Clear chips from drill and work piece with a brush. Never use hands or cloth on a revolving drill.

8. If the hole is to be drilled through the piece, the most critical time is the breaking through point. Disengage the feed and apply light pressure by hand.

   NOTE: Too much pressure will cause the drill to dig in and break or pull itself out of the holding device.

9. Remove the drill from the work and turn off the power.

   CAUTION: Never try to stop a revolving chuck with your hands.

10. Clean cuttings and cutting fluid from the machine.

11. Return the drill to its proper place.

OPERATION SHEET

Operation Sheet No. SL-6-2

HOW TO: Ream on the Drill Press

COURSE OF STUDY: Machine Shop Practice - Drill Press Operation

INTRODUCTION: Reaming is the operation that produces holes that are extremely accurate and have a smooth finish. Reamers are made in a variety of sizes and styles. They are usually made from high speed steel. Some are fitted with carbide cutting edges.

TOOLS AND EQUIPMENT: Drill press, safety glasses, reamer, vise or straps, bolts, and parallels.

PROCEDURE:

1. Select the type and size reamer suited to the job.

   NOTE: Be sure the reamer's cutting edges are sharp and free of nicks and burrs.

2. Mount and secure work to the drill press table.

   NOTE: Work piece may be placed in the vise or clamped directly to the table.

3. Drill hole to be reamed (refer to Operation Sheet No. SL-6-1).

   NOTE: The hole should be drilled 1/64 of an inch smaller than the reamer size.

   CAUTION: Do not move the work piece after it has been drilled and reaming is to follow. If the job is disturbed, it will be hard to line up the reamer with the drilled hole.

   Be sure chuck key is removed from chuck before starting machine.

4. Grip the reamer in a drill chuck.

   NOTE: For taper shank reamers, mount in the drill press spindle or use a sleeve, if necessary.

5. Check run out of reamer by jogging the spindle.

   NOTE: If reamer runs out, recheck for burrs on reamer shank.

6. Adjust drill press for speeds (refer to Information Sheet IL-6-3).

   NOTE: The reamer should revolve at a speed approximately half that of the drill.

7. Start the machine.

8. Lower the reamer to the work and start the cut slowly until reamer has entered the hole, in order to prevent chattering.

   NOTE: If drill press has automatic feed, it may be used to feed reamer into hole. The reamer should not be crowded, if feeding is done by hand.

9. Use ample supply of cutting fluid.

10. Feed the reamer to required depth.

    NOTE: A reamer can be fed faster than a drill of the same size. A reamer should never be run backwards as this tends to break or dull the edges.

11. Stop the machine before removing the job from the work table.

12. Remove reamer.

13. Return all tools and equipment to their proper place.

14. Clean machine.

OPERATION SHEET

Operation Sheet No. SL-6-3

HOW TO: Countersink on a Drill Press

COURSE OF STUDY: Machine Shop Practice - Drill Press Operation

INTRODUCTION: Countersinking is the operation of machining a chamfer or cone-shaped recess at the end of a hole for the purpose of recessing a flat headed screw or just deburring the edges of the hole.

TOOLS AND EQUIPMENT: Drill press, workholding device, and countersink.

PROCEDURE:

1. Secure the work in the workholding device.
2. Select the countersink with the size and angle required for the job.

   NOTE: Countersinks are made with various angles but the most common one is 82°. All flat head screws are made with an 82° angle head.

3. Place countersink in drill chuck and tighten.

   NOTE: Remove chuck key immediately.

4. Adjust the spindle speed to about one-half that used for drilling.

   NOTE: A fast speed will cause chatter.

5. Lower the countersink to the work. Start the machine. Hand feed the tool slowly into the hole to the approximate depth of the diameter of the screw head.
6. Stop the machine. Check the depth by means of a gauge or a flat head screw.
7. Set the depth stop to allow an additional cut for the correct depth.

   NOTE: By using a depth stop for the spindle eliminates the chance of cutting the recess too deep.

8. Finish the cut.
9. Clean the machine and return the tool to its proper place.

OPERATION SHEET

Operation Sheet No. SL-6-4

HOW TO: Grind a Drill

COURSE OF STUDY: Machine Shop Practice - Drill Press Operation

INTRODUCTION: A correctly sharpened drill is important to the machinist. Correct hole size and elimination of overheating are the main benefits resulting from correct drill grinding. Grinding drills by hand requires a great deal of practice.

TOOLS AND EQUIPMENT: Bench grinder, drill, drill gauge, and wheel dresser.

PROCEDURE:

1. True and dress the grinding wheel.
2. Examine the drill to check its condition. If the cutting edges are dull or chipped or the margins are worn or burned, it will be necessary to grind off the whole point and regrind the drill to a new point.
3. Grasp the drill with either hand near the point. Rest the forefinger of that hand on the tool rest and hold the drill against the finger with the thumb.
4. Hold the drill at an angle of 59° to the grinding wheel. Hold the shank with the other hand.
5. Move the drill to the wheel until it touches then move the hand, holding the shank, downward. Hold the drill steady, do not twist it. This steady downward motion will produce the correct curve on the drill surface back of the cutting edge. In scribing the arc, the shank end of the drill should never come up to the level of the cutting edge. If this happens, a negative angle is ground and the drill will not cut.

   CAUTION: Too much pressure applied while grinding will overheat the drill and the rapid cooling in cold water may cause cracks in the metal.

6. Repeat this same operation on the opposite cutting edge.

7. Check the angles with the drill gauge.

NOTE: Correct angles will not result from the first attempt. Plenty of practice will be necessary to achieve good results. Repeated checking will be necessary to produce equal length cutting edges and correct angles. The clearance angle behind the cutting edge should be about 12°.

OPERATION SHEET

Operation Sheet No. SL-7-1

HOW TO:	Use Magnetic Chuck
COURSE OF STUDY:	Machine Shop Practice - Surface Grinder Operation
INTRODUCTION:	The ease and speed of loading and unloading work pieces on a magnetic chuck is one of the major reasons for the use of this device in surface grinding. The use of the magnetic chuck is possible because forces exerted by the grinding wheel on the work piece are relatively insignificant compared to the forces exerted on the work piece by the magnetic chuck. There are two basic types of magnetic chucks: electromagnetic and permanent. The independent use of magnetic chucks is limited to ferrous metals (iron and steel). The magnetic chuck can be utilized for non-ferrous grinding by clamping the work piece to a ferrous plate or fixture.
TOOLS AND EQUIPMENT:	Surface grinder, magnetic chuck, demagnetizer, wheel dresser, and safety glasses.

PROCEDURE:

1. Remove any burrs from the bottom of the chuck and the table surface and wipe each clean.

2. Mount chuck on table surface and clamp into position.

3. Dress wheel fairly coarse or open with a sharp diamond dresser.

   CAUTION: Do not wear a watch while operating a magnetic chuck. There is danger of magnetizing the mechanism and ruining its operation.

4. "Grind in" surface of the chuck. With coolant on and full holding power on the chuck, grind surface flat using .0001 or .0002 inches downfeed per pass with fast table speed and light cross feed.

5. De-energize the chuck and wipe clean.

6. Remove burrs and wipe surfaces clean on work pieces.

   NOTE: Place work pieces in regular pattern on chuck if multiple grinding is being done. All the steel on the chuck face between the brass or lead strips is the magnetizing area when the chuck is energized. For more positive holding action each work piece should span at least one of the steel strips.

7. Mount work piece on chuck and energize the magnetic field.

8. Proceed with grinding operation.

9. When completed, de-energize the chuck and remove the work piece.

   NOTE: To protect the finish of a ground surface and the chuck surfaces it is desirable to place a thin piece of paper between the work piece and the chuck.

10. If a demagnetizer is available, it is desirable to remove residual magnetism from the work piece.

OPERATION SHEET

Operation Sheet No. SL-7-2

HOW TO: Grind a Flat Surface

COURSE OF STUDY: Machine Shop Practice - Surface Grinder Operation

INTRODUCTION: Although all grinding may be considered as surface grinding (in that a surface is being ground), the industrial classification of surface grinding involves grinding a flat surface. The primary objective of flat grinding, other than flatness, is to produce a surface that is free from waviness. Surface flatness can be checked by using a straight edge or dial indicator. Characteristics of the material being ground and finish qualities desired will determine the type of wheel and feed and speeds.

TOOLS AND EQUIPMENT: Surface grinder, diamond wheel dresser, surface plate, magnetic chuck, straight edge and/or dial indicator, and demagnetizer.

PROCEDURE:

1. Mount the proper wheel on the spindle.

2. True and dress the wheel.

3. If a magnetic chuck is being used, "grind in" the chuck.

4. Mount work piece on the chuck or secure it to the table.

   CAUTION: Check the holding power of the chuck by grasping it and trying to move it. If the work piece is being clamped to the table, be careful not to warp it.

5. Select proper feed and speed.

6. Adjust table stops.

7. Turn on spindle and coolant motors.

8. Downfeed the wheel until it touches the highest point of the work piece.

   NOTE: For rough grinding, a downfeed of .001 to .003 inch per pass is used.

9. Adjust table to move work piece to starting position for rough cut.

10. Adjust wheel for depth of cut.

    NOTE: To begin, follow the general principal that cross-feed increments should be .030 to .050 inch.

11. Adjust table to move work piece to starting position for finish cut.

    NOTE: For finish grinding, a downfeed of .0001 to .0002 inch is used. Dress wheel before taking a finish cut.

12. Adjust wheel for depth of finish cut.

13. Before stopping the wheel turn off the coolant to allow the coolant to be thrown from the wheel so that the wheel will remain in balance.

14. A demagnetizer (if available) should be used to demagnetize the work piece.

    NOTE: Some magnetic chuck models have a demagnetizing arrangement built into the chuck system.

OPERATION SHEET

Operation Sheet No. SL-7-3

HOW TO: True and Dress a Grinding Wheel

COURSE OF STUDY: Machine Shop Practice - Surface Grinder Operation

INTRODUCTION: One of the prerequisites for efficient and effective grinding is a properly dressed wheel. The dressing serves to expose new and sharp cutting edges to the grinding surface. An important point to remember is that it is essential that the wheel be trued before dressing, that is, all points on the periphery of the wheel must be concentric with the center of the wheel. The most common means of dressing a grinding wheel is by using a diamond imbedded in a steel shank.

TOOLS AND EQUIPMENT: Surface grinder, diamond wheel dresser and safety glasses.

PROCEDURE:

1. Mount wheel to be used on spindle.
2. Mount diamond dresser on table or magnetic chuck.

   NOTE: Some diamond holders have an arrow to indicate the direction in which the holder should be placed on the table in relation to the wheel rotation.
3. Adjust the wheel height and table until the wheel is close to the diamond.
4. In most applications the dresser is located about 1/4" to the left of the vertical center line of the wheel.
5. In the truing operation, lower the wheel until the highest point on its periphery touches the diamond.

   NOTE: This prevents the diamond from taking too deep a cut.
6. Cross feed the table so the diamond moves back and forth across the face of the wheel.

   NOTE: If coolant is to be used in the grinding process, it should also be used when truing and dressing.

7. Adjust the wheel downward .001 or .002 inch per pass for rough truing and .0005 inch for final pass.

   NOTE: It is very important to have a sharp diamond for truing and dressing.

8. Dressing is accomplished by repeating step 7.

   NOTE A trued wheel may not be properly dressed. Important criteria for a properly dressed wheel is flatness, freshness, cleaness, and consistent color. A general rule of thumb to follow is tc dress the wheel to a depth at least equal to the depth of cut being taken.

OPERATION SHEET

Operation Sheet No. SL-7-4

HOW TO: Square Stock

COURSE OF STUDY: Machine Shop Practice - Surface Grinder Operation

INTRODUCTION: Squaring stock refers to the operation of machining material into a form having straight sides and right angles. Work that requires a good surface finish, in addition to being square, is done on the surface grinder. The material is usually rough machined elsewhere before being delivered to the surface grinder for machining the final dimensions.

TOOLS AND EQUIPMENT: Surface grinder, diamond dresser, and safety glasses.

PROCEDURE:

1. Inspect and clean surface of magnetic chuck.

2. File burrs from surface of work that is to come in contact with the chuck.

3. Center the work on the chuck and energize the magnet moving the lever to the "on" position.

   NOTE: Check the holding power of the chuck by grasping the work piece and trying to move it.

4. Adjust the table stops and table feeds if available.

   NOTE: Consult with your instructor about setting table feed. Each make or model of a surface grinder differs somewhat in its adjustments.

5. Downfeed the grinding wheel until it touches the highest spot on the work piece.

   NOTE: The work piece must be moved back and forth under the grinding wheel, either by hand or by machine, traverse until the high spot is found. The cross feed, is available, should be set at this time.

6. Start to traverse the table and feed the work piece for the rough grind. Check progress of cut then adjust coolant if available.

7. Continue feeding downward in increments of 0.001 inch until the grinding wheel covers the entire surface. The number of rough cuts depends upon the beginning surface.

8. Dress wheel before the finish cut (refer to Operation Sheet No. SL-7-3). Downfeed should be 0.0005 inch or less, depending upon the quality of surface finish desired.

9. Before stopping the machine refer to Operation Sheet No. SL-7-3 if coolant is being used. Otherwise stop the machine.

10. Move work piece away from wheel and turn chuck lever to "off" position.

11. Remove work piece from chuck and file burrs.

12. Clean chuck surface.

13. Replace work piece on center of chuck with the finished surface down.

14. Reactivate chuck magnet and check for holding power on the work piece.

15. Repeat steps 5 through 12.

16. File all burrs.

17. Clamp a finished surface to a parallel or angle plate. Make sure the top surface of the work piece is above the top edge of the parallel or angle plate.

18. Use a surface gauge or an indicator to level the top surface of the work piece in preparation for grinding.

19. Repeat steps 3, and 5 through 12.

20. File all burrs.

21. Repeat steps 13 and 14.

22. Repeat steps 5 through 11.

23. Clean entire machine and replace tools.

OPERATION SHEET

Operation Sheet No. SL-7-5

HOW TO: Mount a Grinding Wheel

COURSE OF STUDY: Machine Shop Practice - Surface Grinder Operation

INTRODUCTION: To insure safe and efficient operation, a grinding wheel must be properly mounted. Extra caution during this sequence of the grinding operation will eliminate many difficulties that could possibly arise later.

TOOLS AND EQUIPMENT: Surface grinder, grinding wheel, and safety glasses.

PROCEDURE:

1. Before mounting, the wheel to be used should always be "ring" tested.

   CAUTION: The "ring" test does not give positive proof that the wheel is sound.

2. Carefully clean the surfaces of the wheel, spindle, blotters, and flanges that will come in contact with one another.

3. Mount inside flange and blotter.

   NOTE: Always use blotters when mounting a wheel.

4. Mount grinding wheel.

   CAUTION: The bore of the wheel should be the same diameter as the spindle or wheel adapter.

5. Mount outside blotter, flange, and nut.

   CAUTION: Tighten the nut firmly, but not so much as to set up excessive strain in the wheel.

6. Apply a "run-in" test by running the wheel at operating speed for about one minute before applying it to the work.

   CAUTION: When applying this test, stand to one side and always have the wheel guard in position.

7. The wheel should now be ready for truing and dressing.

   NOTE: The wheel adapters on some grinders have provisions for statically balancing the wheel.

OPERATION SHEET

Operation Sheet No. SL-8-1

HOW TO: Harden and Temper Tool Steel

COURSE OF STUDY: Machine Shop Practice - Heat Treatment

INTRODUCTION: Hardening is the process that changes the physical properties of steel by heating and rapid cooling. There is a higher percentage of carbon in tool steel than in cold rolled steel. When steel has enough carbon, it becomes very hard after it is heated to a high temperature and cooled quickly in water or oil.

Tempering is a process of reducing the degree of hardness and strength and increasing the toughness. The tempering process always follows the hardening process.

TOOLS AND EQUIPMENT: Safety glasses, heat treatment furnace, quench tank with water, suitable tongs, old file, asbestos gloves.

PROCEDURE: A. How to Harden a Piece of Carbon Tool Steel

1. Start up the furnace.

   NOTE: If it is electric, set pyrometer to desired temperature, turn on main switch. If gas furnace, light the furnace and adjust the flame. Do not stand in front of or look into the furnace when lighting it. Check Operator's Manual for other operating instructions on the furnace you are using.

2. Select tongs that fit the work.

   CAUTION: Wear safety glasses and asbestos gloves when working around the furnace. Be careful not to pick up tongs or steel without first checking to see if they are hot.

3. Place work in furnace.

4. Close furnace door.

5. Allow furnace to come up to correct hardening temperature.

   NOTE: The critical point or critical temperature is the point at which the steel has the most desirable characteristics. When steel reaches this temperature, somewhere between 1400° F and 1600° F, the critical point is reached. The change is ideal to make for a hard, strong material--if it is cooled quickly.

   Preheat the jaws of the tongs before removing heated piece from furnace. This will prevent cold spots from appearing on the heated piece, if touched by the cold jaws.

6. Remove the work from the furnace and quench in water or oil, depending upon the type of steel used, i.e., water hardening or oil hardening steel.

   NOTE: The heated piece should be dipped quickly into the water. It is important that it be moved about or agitated in the water to prevent steam pockets from forming.

7. Test for hardness by trying to file the surface of the work. If the piece is hard, the file will slip over the surface without scoring.

   NOTE: Do not use a new file for testing hardness. The cutting edges will be destroyed and the file becomes useless.

B. How to Temper a Piece of Carbon Tool Steel

1. Polish the surface of the hardened piece with abrasive cloth.

   NOTE: Cleaning off the scale with abrasive cloth enables you to see the tempering colors more clearly. If the furnace has a pyrometer, step 1 may be omitted (refer to Information Sheet No. IL-8-5).

2. Place piece in draw (tempering) furnace and close door.

   NOTE: If furnace is a two chamber furnace, the lower chamber is the draw (tempering) furnace (or low heat furnace--temperature up to 800° F only). If the furnace is not a two chamber furnace, place piece in furnace and reduce heat to required tempering temperature.

3. When the proper heat or color has been reached, removed piece from furnace and quickly quench.

4. Shut off furnace.

OPERATION SHEET

Operation Sheet No. SL-8-2

HOW TO: Caseharden Low Carbon Steel

COURSE OF STUDY: Machine Shop Practice - Heat Treatment

INTRODUCTION: Casehardening is a process of hardening the outer surface or case of low carbon steels. When adding a small amount of commercial hardening compound to the outer surface, it can be heat treated to make the surface hard. The core or center remains soft and ductile.

TOOLS AND EQUIPMENT: Furnace, asbestos gloves, safety glasses, tongs, quenching tank or container, hardening compound.

PROCEDURE:

1. Start the furnace (refer to Operation Sheet No. SL-8-1 for starting the furnace).
2. Place work in furnace, heat to salmon color (1650° F).
3. Grasp work with tongs, remove from furnace.
4. Coat with casehardening compound.

   NOTE: One of two suggested nontoxic compounds, such as "Kasenit" or "Royal Hardening Powder," may be used.

5. Replace piece in furnace.
6. Reheat to a salmon color (1650° F).
7. Remove from furnace with tongs and quench in water.
8. Repeat the whole procedure if deeper penetration is desired.
9. Shut off furnace.

   NOTE: A work piece that is casehardened cannot be ground because the case or hardness penetration is not deep enough. Grinding would remove the hardness skin.

OPERATION SHEET

Operation Sheet No. SL-8-3

HOW TO: Anneal Tool Steel

COURSE OF STUDY: Machine Shop Practice - Heat Treatment

INTRODUCTION: Annealing is the process of softening tool steel. This makes it easier to machine. The steel is heated above the critical temperature and cooled slowly.

TOOLS AND EQUIPMENT: Furnace, asbestos gloves, tongs, and safety glasses.

PROCEDURE:

1. Start up furnace (refer to Operation Sheet No. SL-8-1 for starting the furnace).
2. Select tongs that fit the work piece.
3. Place work in furnace.
4. Close furnace door.
5. Heat work to critical point.

   NOTE: The temperature required for annealing of steel is slightly above the critical point (the temperature at which internal changes take place in the structure of the metal). The critical point varies, of course, with different steels. Some typical annealing temperatures are: low-carbon steel, 1650° F, and high speed steel, 1400° F. The temperatures should not be more than 50° to 75° F above the critical point.

6. Turn off the furnace, allowing the metal to cool slowly.

   NOTE: A maximum cooling rate of 50° F per hour down to 1000° F is suggested.

7. Return tongs, or any equipment that was used in the procedure of annealing steel, to proper storage places.

OPERATION SHEET

Operation Sheet No. SL-8-4

HOW TO: Flame Harden

COURSE OF STUDY: Machine Shop Practice - Heat Treatment

INTRODUCTION: Flame hardening is a process that involves the rapid heating of the work piece by using an acetylene torch and then quenching. This process is ideally suited for work pieces that are small in size. Since flame hardening is used in many applications involving small tools, the time span between heating and quenching should be as short as possible. Flame hardening, as other surface hardening methods, requires tempering to remove brittleness and relieve stresses.

TOOLS AND EQUIPMENT: Acetylene torch, water quenching tank, tongs, asbestos gloves, and safety glasses.

PROCEDURE:

1. Using an acetylene torch, heat the work piece to the critical temperature.

   NOTE: Since the work piece is heated in the open, it will be necessary to estimate the temperature from the color of the work piece caused by the conduction of heat.

   CAUTION: Take care to keep the heat evenly distributed and not excessive to the extent that the work piece warps.

   NOTE: Be sure to use a steel of proper carbon content to achieve the hardness desired.

2. At critical temperature quickly quench the work piece in the quenching medium.

3. To temper, heat to critical temperature and quench.

   NOTE: There is a significant difference between hardening and tempering temperatures.

Section 8

INFORMATION SHEETS

and

ASSIGNMENT SHEETS

Information Sheets supplement the job sheets and provide the student with related information necessary for completing the assignment jobs with the highest possible degree of understanding. The information units that will be stressed in this course are listed in Section 5C.

Assignment Sheets supplement a textbook which will be used in the course. These sheets provide the student with mental activities necessary to learn the "knowing" that accompanies the "doing" of an occupation.

The Information and Assignment Sheets should be prepared by each instructor.